Instruments

THE MAGAZINE OF

Measurement and Control

Vol. 18
JULY
1945
No. 7

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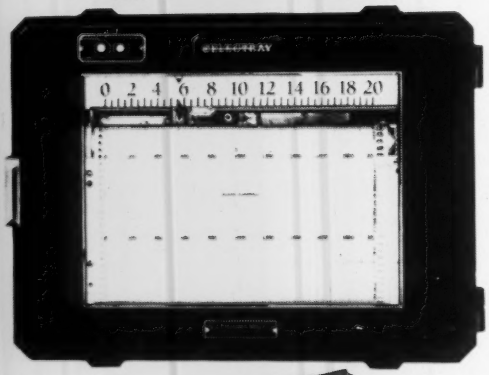

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Instruments

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Instruments THE MAGAZINE OF Measurement and Control

M. F. BEHAR, Editor

No Royal Road to Accuracy

EVERYBODY knows that this is the age of labor-saving machinery for the factory, of labor-saving machines and devices for offices, stores and farms, and of labor-saving appliances for homes. Everybody knows, also, that America is the birthplace of labor-saving machines, appliances and gadgets. Almost everybody knows that our mechanical servants which relieve us of repetitive drudgery are AUTOMATIC. Some are full-automatic, some are semi-automatic, but their common attribute is automaticity. Nobody appreciates the blessings of automaticity more keenly than do you readers of *Instruments*.

What the general public does not appreciate is that automaticity is based on measurement. Without some sort of measurement there can be no automatic action. The measurement need not be continuous; nor even performed by a measuring instrument; but it must be made. Even the simplest and oldest automatic devices must incorporate measuring elements in order to function. Consider for example an eighteenth-century automaton displayed in a museum or written up in an encyclopedia: every stroke-reversing mechanism in it embodies a crude equivalent of the modern limit switch and is so positioned that the length of stroke is neither too long nor too short. Therefore it is a LENGTH-MEASURING ELEMENT, or ANGLE-MEASURING ELEMENT, although the original inventor probably did not think of it in such terms and certainly did not talk about it in such terms.

It follows that the measurement must always be reliable and "accurate." There can be no question as to the necessity of reliability; the importance of accuracy, however, is relative—because "accuracy" is almost always a relative term and almost never an absolute term. The distinction hinges, first of all, on what is being measured. If someone shows you a fuze body and seriously tells you that its length measures 2.13063593″ by his machinist's micrometer, you will be inclined to make him measure his length on the floor; but if he mentions that the counter on turret lathe No. 65 shows an output of 3197 fuze bodies during the swing shift, you accept that figure as ABSOLUTELY accurate.

Counting is a field of measurement where absolute accuracy is possible. It is such a special case that "accuracy" and reliability" become almost synonymous. A reliable counter is absolutely accurate; a counter is either absolutely accurate or completely out of order.* There is no such thing here as degree of precision. On the other hand it is obvious that accuracy in measuring the length of the fuze body depends on the degree of precision of the gage and on the degree of precision of the method. . . . *And* on care and skill if the limit of error must be within 0.01%.

Care, skill, experience, knowledge, ingenuity, resourcefulness and common sense become important factors when VARIABLES are to be measured—as they must be if they are to be controlled. Temperature, pressure, humidity, flow-rate, acidity or alkalinity, liquid level, speed, voltage, frequency . . . you can't always measure such variable conditions and properties as easily as the length of a fuze body!

And you can't always "put it up to the instrument manufacturer." No single instrument company makes every type of thermometer, or tachometer, or hygrometer, or flowmeter, or voltmeter, or pressure gage. Moreover, "the higher the fewer." Hundreds of companies make thermometers but few make high-precision quick-response thermometers and none has ever made an instrument for recording to 5°F. accuracy the cyclic temperature variations of a given point 0.001″ below the working surface of an engine piston.

Too many industrial executives "solve" measurement and control problems by ordering "the best instruments money can buy"—and then closing their ears to the recommendations of their own Instrument Men.

Consider in particular the measurement of flow rate. If your problem is a simple one—say, cold water in a 2″ pipe and no violent surges—then you can order a flow recorder from any of several companies' catalogs and it will be easy to follow the installation instruction-sheet so that the overall accuracy of the whole metering system from orifice plate to recorder chart and integrating register will be equal to the guaranteed accuracy of the recording-integrating instrument. But such ease is the exception in flow measurement and control. At the other extreme is the measurement of pulsating gas flow—a problem not yet fully solved. In between are innumerable cases where the orifice installation and piping arrangement may cause errors five to fifty times as great as those resulting from the mechanical imperfections of the instrument.

Yes, it is true that the ASME, the AGA, the Bureau of Standards, several universities, several oil and gas companies, and dozens of flowmeter manufacturers have developed orifice metering from an art to an exact science. It is true that the user need not "design an orifice" in the sense of designing its bevel angle, its ratio of zeta to dam height, etc. It is true that the simple computation which many users call "designing" is essentially "sizing," i.e., determining the correct diameter of the hole in the plate which they can buy ready-made. It is true that they can buy the recording-controlling instruments ready to use, as well as the control valves, the traps, the seals, the gage lines, the air lines, and all necessary fittings. But in this field of flow measurement and control (perhaps even more than in the measurement and control of other variables including temperature) nothing that research bodies and instrument manufacturers have done in the past or can do in the future will ever serve as a substitute for the user's acceptance of his responsibilities when Accuracy is required.*

Yes, even for a cold-water flowmeter installation, the user SHOULD read and follow the instructions; for complex gases and liquids he MUST do so and more: he himself must know, BEFORE he orders his orifice plate and the other manufactured products, when and where to use factors of Supercompressibility, Expansion *Y*, Thermal Expansion, Reynolds Numbers, pressure-tap location corrections . . . and numerous other details. If he wishes Accuracy he must have a strong backbone as well as a passionate wishbone. In short, he himself must be in fact, if not by title, a Plant Flowmeter Engineer or Flowmeter Installation Engineer.

And so it goes in every field of Instrumentation! The goddess of Accuracy demands from her priests a sense of responsibility, keen brains and a life of devotion.—MFB

*We refer, of course, to the counting instrument itself. It is possible that a small degree of inaccuracy or unreliability or uncertainty will result from the installation or method of use. For example, every type of counter has its operational speed limit.

*See for example "Selection and Installation of Flow Meters" by R. E. Sprenkle, *Instruments*, Vol. 15, March 1942, pages 75-82; also the same author's "Piping Arrangements for Acceptable Flowmeter Accuracy," *Transactions A.S.M.E.*, Vol. 67, July 1945, pages 345-360.

How to Get The Most Out of Your "Metered-type" Automatic Control

By CLARK E. HAGUE, Cleveland District Manager, Askania Regulator Co.

IF industry is to derive from the use of metered control the benefits that are available, it must concern itself with research and educational work. It is not sufficient that there be available in each plant some individual or department capable of making a repair in case of trouble. It is more important that those who use the control be familiar with its scientific purpose and alert to discover and record the effect of measured changes in the functions of the processes being controlled.

It follows, of course, that if metered control is to be used as the means for conducting research (and therein lies its most immediate use), it must be accurately calibrated, scientifically and carefully installed and the controlled functions recorded in standard units of measurement. It follows also that if the control is to be accurately calibrated and its functions recorded, the signals from the primary elements must be true and accurate measurements of the functions they represent.

Physical conditions of space, existing equipment, pipe sizes, etc., are ever-present temptations to compromise the provisions for correct metering. This is especially true where air is to be metered for combustion control purposes. The air lines are usually large by comparison with the fuel lines and invariably present the greatest metering difficulties and, since air is cheap, it is difficult for many engineers, and still more executives, to understand why they should spend good money to meter it. The answer is, of course, that good control cannot be had unless the air is as correctly metered as the fuel.

The belief is still quite general that the purpose of combustion control is to save fuel. That is, of course, a worthwhile purpose although it is usually one of the lesser benefits growing out of a combustion control application. The total fuel used on the average steel heating job is worth usually less than 2% of the value of the product passing through the furnace; hence any benefit such as greater uniformity in heating, or control of scale formation which increases yield or decreases rejections or aids in pickling or reduces roll breakage, pays a dividend which may be greater than could be hoped for in the reduction of fuel alone.

Until quite recently the steel industry has made its experiments with metered control on equipment which was not designed with the use of control in mind, and in some cases the results have been disappointing because the equipment to be controlled was not controllable. In some cases, valves of wrong size or wrong flow characteristic were used. In some cases, furnaces with inadequate flues, stacks or tunnels were equipped with controls and in still other cases controls have been expected to correct the faults of poorly designed burners or furnace contours, and, in far too many cases, the effectiveness of controls is handicapped with makeshift metering conditions.

Even in these cases of misapplication however, the controls have proven their usefulness by pointing the way to, and bringing about needed changes and improvements, and by instilling in the operating crews a tendency toward more careful operation and a better understanding of their equipment.

In the writer's opinion, the proudest chapter in the history of metered control thus far is its record of pointing the way to better practice and, if as seems indicated, metered control is to provide the medium of language by which you will study and record your process and, at the same time, serve as the tool by which you will translate your studies into practice, it becomes of the greatest importance that errors in its application, installation and use be avoided.

For some reason there is a persistent belief among some plant engineers that although an orifice and its connections to an ordinary recording flowmeter must be arranged with the greatest precision, a similar orifice and connections to a control instrument can be stuck in most anywhere. Of course it is important that both types of installation be made correctly but, if one must be done with less exactness than the other, the control should have the better signal, since, while the meter will do no worse than draw an incorrect chart, the control can actually be the cause of waste or the spoiling of product. The control is related to the process and the meter is simply drawing a line of record.

Among the more persistent of the recurring errors in the application of control is the characteristic tendency of the steel mill engineer to determine how large a thing should be and then make it twice that big. When this rule is applied to a control valve, the result is always bad. I recall one case in a local plant where the plant engineer insisted upon using an 8" butterfly valve on a certain job where the control people had specified a 4" valve. The discussion became an issue with the result that the job was placed with a competing company who, when the job was finally working properly, were using a 3" valve. The 8" valve was tried, then a 6" installed and found too large, and finally the 3" was tried and found to be amply large.

Still another case was where a large butterfly valve was used to reduce gas pressure to a process where only a small amount of gas was used. The valve leaked more gas than the process required most of the time and all the regulator could do was to hold the valve closed while the pressure meandered all over the chart. The engineer insisted that the regulator should have more power in order to hold the valve more tightly closed although it was a full-turning butterfly valve.

Adequate information for the calculation of butterfly valve capacities is available and should be used wherever these valves are applied as a control means.

Another common error occurs frequently in the locating of simple pressure taps. It is quite common to find the conventional diaphragm-operated globe-pattern pressure-reducing valve in use as a part of a complicated system of control involving temperature control, combustion control, furnace pressure control, etc., where each piece of control is related to all of the other pieces and must perform its function in timing with them. These valves are likely to be installed at a point some distance away from the rest of such a control system in order that the safety shut-off valves, etc., may be inserted downstream from them. Their pressure-measurement taps are usually taken directly from the valve body and if there are elbows or other flow-resisting influences between this valve and other items of control in the system, the result will be to change the pressure on the system with each flow change, making the entire system unstable.

A case illustrating this point was a gas mixing station for mixing blast furnace gas and coke oven gas. Orifices were provided in each of the gas lines and a proportioning regulator operated a butterfly valve in the coke oven gas line to maintain the flows in proportion. A diaphragm-operated globe-pattern valve was in use ahead of the mixing station to maintain a constant pressure on the coke oven gas metering orifice. Between the diaphragm-operated valve and the mixing station were two elbows in the coke oven gas line. The whole system hunted badly until the pressure tap for the diaphragm-operated valve was moved to a point *after* the two elbows. This simple change cured the entire trouble.

*Presented before the American Society for Measurement and Control, Pittsburgh, March 26, 1945.

The simplest forms of control are those wherein the effect of regulation is immediately registered at the point of measurement; for example, a flow control to maintain a constant differential across an orifice, the orifice being located ahead of the control valve and just far enough away for good metering conditions. Another example is a pressure control for a pressure system wherein the volumetric capacity of the system is small by comparison with the rate of flow through it.

It is not uncommon for these otherwise simple jobs of control to be seriously complicated by locating control valves too far away from orifices or from pressure-measurement points or by having supply lines to pressure systems so small that a lag in response to regulation is introduced.

The size of the gage line (from pressure tap to deflecting element) is frequently the cause of trouble, especially in low-pressure work where metering diaphragms are required to be large and the breathing of the diaphragm causes some movement of gas in the gage line. It is not uncommon for a regulator to be operating on 0.01" water column and, for such an installation to operate properly, the regulator must respond to pressure changes of about 0.001" water column.

It is easy to see that if the gage lines to such an installation are so small as to resist the breathing of the metering diaphragm, or cause an excessive rate of movement of the gas in the gage line as the pressure values change, the value of the signal when it reaches the diaphragm will be considerably altered and delayed in transmission, and if the pressures are changing rapidly the true value of the pressure may never be transmitted to the regulator.

Any piece of control that includes a fluid metering element can reasonably be expected to operate accurately only within the range of its metering element. For example, a flow control that is actuated by the differential across an orifice. The orifice, as a means of measuring flow, is accurate through a turndown range of only about five to one, or from 100% to 20% of flow, yet regulators in flow control applications are called upon to operate far beyond this range and do a surprisingly good job through ranges of ten to one.

The ratio control is especially affected by this limitation since it is actuated by the *difference* between *two* metering differentials, and if either of the measurements is in error, the resulting regulation must be in error unless the other measurement is in error also by the same amount and in the same direction.

This metering limitation is also a factor in limiting the range through which a proportioning regulator can be adjusted for varying the ratio of two flows. We are frequently called upon to produce a proportioning regulator which will control the mixing of two gases through the entire range from 100% of the primary gas and none of the secondary gas, to none of the primary gas and 100% of the secondary gas. This obviously is not possible to do with a single set of orifices and a single regulator. It can and is being done by maintaining constant differentials across variable orifices and can be done quite well by using different sets of orifices for different parts of the range.

It is essential, of course, that a manufacturer of control equipment be familiar with the magnitude and behavior of the forces available from a metering installation, for it is only because these forces behave according to definite laws that he is able to fashion his product to their use. He knows too that any valve, or other device to which his control is applied, will respond to adjustment or movement in accordance with some definite law and that it is the purpose of his device to bring these possibly divergent laws into an orderly relationship of cause and effect, yet through pressure of competition, or time, or lack of money or lack of comprehension of these laws by the purchaser, he must often accept compromises which seriously affect the result of control.

"It is wrong to think of any part of a control installation as being unimportant, for each part is related to the whole."

"It is not uncommon for simple jobs to be complicated by locating control valves too far from pressure-measurement points or by having supply lines to pressure systems too small."

"The speed with which a furnace or a turbine or a process will respond to regulation is usually unknown until after the control installation is put into use, and unless the control instruments are capable of being brought into synchronization with this speed of response, hunting is sure to occur."

It is wrong to think of any part of a control installation as being unimportant, for each part is related to the whole. A poorly fitted pin in a mechanical linkage can spoil the operation of an entire installation. A valve whose mechanical travel is greater than its effective travel as a throttling means has the same effect as exaggerated lost motion in the mechanical linkages. Friction in the mechanical linkages which prevent the smooth operation of the controlled parts is a comon cause of trouble and often adds much to the cost of control equipment for, generally speaking, the cost of control is related to the amount of work it must do.

Just as it is important to install pressure-connection lines from orifices or pressure taps with provisions for draining out moisture, so is it important to install oil lines for power transmission with provisions for removing air, for if air is trapped in the oil lines of a hydraulically-operated control system, the compression and expansion of the air will cause the installation to hunt. This condition will be more exaggerated where friction exists in the controlled parts and considerable force is required to start them in motion. Means for removing air should be provided at the high points in all oil transmission lines.

It is entirely natural, I suppose, for an engineer or an operator who finds himself in charge of an expensive installation of control and recording apparatus, to hope and strive for nice even legible recorder charts and, to this end, it is quite common to find that gage lines have been restricted to the extent that they do not transmit a true measurement of the condition they are intended to measure. It should be borne in mind that charts are intended to portray an honest record of conditions as they are and that the true condition is not improved by falsifying the record.

There is a tendency that I have noticed among department control, to lock all of the adjustments and to forbid everyone, including the operators in charge, making any changes in the settings. (There is, of course, a very real reason for this tendency: the boss will be around sooner or later and will be sure to try all of the wheels that will turn!) I doubt the wisdom of this practice, however, insofar as the operators are concerned, for I find them as interested as their superiors in learning the uses and limitations of new equipment and, usually, when a piece of equipment is damaged by them it is because they have *not* been instructed sufficiently in its use. Rarely are they given adequate instruction and frequently they are led to believe that all they need to do after the control is put into use is to let the control have its way and all of their troubles will vanish.

Unfortunately, controls cannot think. They can only do what you set them to do, and if you set them to do the wrong thing, they will do it just as faithfully as they will do the right thing. The function of automatic control is to do something a little more accurately, a little more punctually and a little more reliably than you can do it by hand, but without a guiding intelligence, it is all but useless and without some experimentation to discover optimum conditions, you cannot know whether you are getting from it all that it has to give.

In the open hearth field particularly, where the use of forced air fans, combustion, furnace pressure, heat input and reversing controls is increasing very rapidly, the writer expects to see within the next few years, as a result of thoughtful operation with these devices, a decided influence upon the design of the furnaces themselves. Certainly, greater liberty in the design of ports should be possible. Furnace life should be improved, and with controlled velocities, checker designs may be af-

Continued on page 494

An Anticipatory Method for Improving Automatic Temperature Control

By M. J. MANJOINE, Research Engineer, Westinghouse Electric Corp., East Pittsburgh, Penna.

IN many applications of conventional temperature controllers excessive hunting and overshooting of the temperature are encountered. To improve the sensitivity and response of these controllers a vacuum-tube thermocouple device was developed at the Westinghouse Research Laboratories. This pilot furnace, called the "Anticipator," minimizes the cyclic swings in temperature characteristic of most furnace controls by anticipating changes in the main furnace temperature and initiating corrective steps.

The anticipator consists of two "bucking" thermocouples of different thermal capacities and an electric heating element, enclosed in an evacuated tube. A schematic sketch of a typical electric furnace installation is shown in Fig. 1.

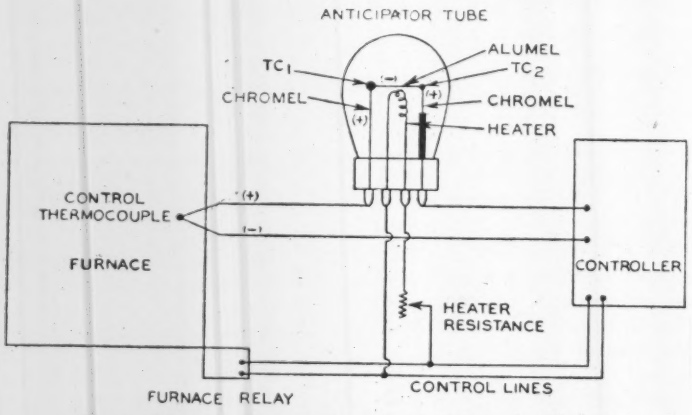

Fig. 1. Schematic diagram of an electric furnace installation.

The anticipator tube has been magnified to show details of its construction. The thermocouples of the anticipator are connected in series with the conventional control thermocouple so that the polarity of the thermocouple with less thermal capacity (TC_2) is additive and the polarity of the couple with greater thermal capacity (TC_1) is subtractive with respect to that of the furnace couple. The electric heating element of the instrument is energized by the power source connecting the control mechanism and the relays that operate the main contactors. Thus the tube and furnace heating elements operate together.

Both thermocouples of the tube are heated but the couple with less thermal capacity reacts first to changes in heater element temperature. The anticipator, therefore, produces an e.m.f. which corresponds to the *rate of change* and the direction of change of the temperature being controlled. The thermocouple e.m.f. from the instrument is given in Fig. 2 for short and long heating-cooling cycles. The short cycle is the normal cycle when controlling at a fixed temperature.

When the two couples in the anticipator are at the same temperature, the voltage from the control couple to the controller is unaffected. At the time that the control thermocouple institutes a change in control current—for example, starts the heating part of the cycle—the change is felt first in the two thermocouples in the anticipator. However, the thermocouple with lower thermal capacity heats faster than the other and the thermocouple voltage at the controller is increased. This increased voltage causes the controller to change to cooling, thus preventing the furnace temperature from overshooting the desired maximum. When the opposite action takes place and the furnace is in the cooling portion of the cycle, the anticipator thermocouple with the larger thermal capacity cools more slowly, and its reversed polarity causes the controller to change to heating and keeps the furnace from overshooting below the desired furnace temperature.

The frequency of the cycle can be changed by the variable resistance in series with the heating element of the tube. If the cycle is made long enough or if the furnace control is set to another temperature, the long cycle occurs (Fig. 2). During long heating the e.m.f.

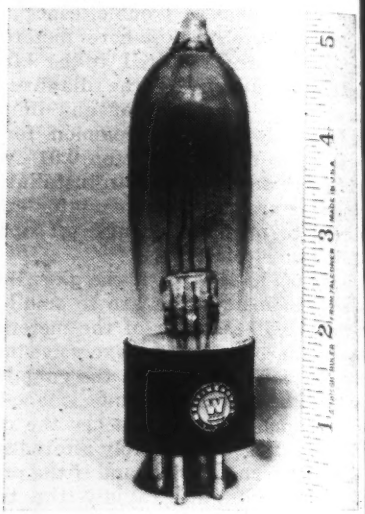

Fig. 3. The new vacuum-tube thermocouple "pilot furnace" device which increases the sensitivity of conventional temperature controls for furnaces by 1000 percent. The device anticipates temperature changes in the main furnace and acts to keep the temperature constant.

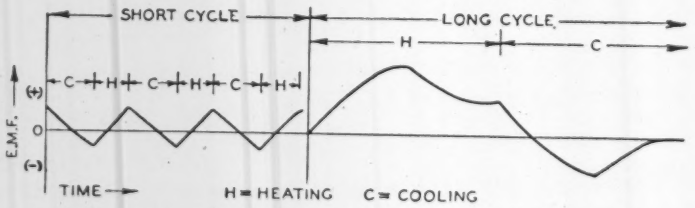

Fig. 2. Anticipator voltage curves during heating and cooling cycles.

of the anticipator reaches a maximum and then decreases to an equilibrium voltage which is positive. This characteristic prevents overshooting when the main furnace is being heated to a higher temperature. The e.m.f. on cooling in the long cycle is nearly the reverse of the forward voltage and approaches zero at the end of the cycle. This latter portion of the cooling cycle is usually interrupted by the controller action.

Since a controller equipped with this device receives the sum of the furnace control couple voltage and the anticipator couple voltage, the controller does not indicate the furnace temperature. In many cases the furnace temperature is read by a second thermocouple in the furnace or on the "work." If the same thermocouple is used for control and reading, a simple shorting switch can be placed across the thermocouples of the anticipator. The control instrument will then indicate the furnace tempera-

ture when the anticipator thermocouples are shorted.

The thermocouples of the anticipator shown in Fig. 1 are chromel-alumel and alumel-chromel, but the anticipator can be made with any two thermocouples of the same materials connected back-to-back. The lead wires of the thermocouples are then of the same material and the instrument can be used with any standard thermocouple. The anticipator tube is compact enough to fit inside many standard controllers or be placed at any convenient point in the control couple circuit. A photograph of an experimental model is shown in Fig. 3. The elements are placed in an evacuated tube to protect them from dirt and tampering, to cause heat transfer to thermocouples by radiation, to minimize the effect of room ventilation and temperature, and to prevent deterioration of the elements.

As an example of the efficacy of this device, a variation of 50°F. (± 25°F.) in the temperature of a large heat-treating furnace was reduced to 5°F. (±2.5° F.) upon connecting and adjusting the anticipator. In another installation on a smaller furnace of a creep testing unit, the temperature fluctuation was reduced from ±2.5°F. to ±0.4°F.

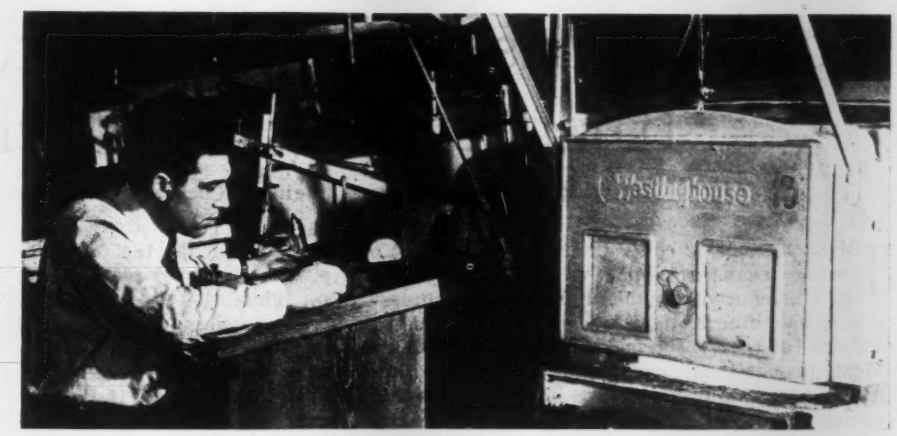

Fig. 4. The anticipating vacuum-tube temperature control device is shown in use by the author. The device consists essentially of two thermocouples of different thermal capacities and an electric heating element. When the main furnace current is on, the anticipator heating element heats both thermocouples, but one heats faster because of its lower thermal capacity. This increases the thermocouple voltage and the control swings to cooling, preventing overshooting. When the main furnace current is cut off, current to the anticipator heater also ceases and both couples begin to cool. The second thermocouple, having greater thermal capacity, cools more slowly. The thermocouple current drops because of the reverse polarity, and the control swings to heating, preventing overshooting. A resistor controls the frequency of the anticipator heating and cooling cycle.

The allowable temperature fluctuation and, therefore, the frequency of the heating and cooling cycle depend on the particular application. The anticipator affords a means of regulating the temperature cycle in accordance with the allowable temperature fluctuation without imposing a duty on the control equipment heavier than necessary. Since the anticipator causes the thermocouple voltage at the controller to fluctuate through a faster cycle, the controller response is more positive, and less chattering of relays is encountered.

Note on the Fusing of Instruments

The Inquiry

To the Editor of *Instruments*:

I have a volt-ohm-milliammeter (a d'Arsonval movement with a d-c. sensitivity of 5000 ohms per volt, a-c. sensitivity not known), and wish to make a pair of fused test leads for it. Please give me information on the following:

(1) I understand that fuses have a certain amount of resistance. Please tell me how these fuses will affect the accuracy of the readings on the various a-c. and d-c. voltage and current ranges, and ohmmeter ranges. Will the effect be small enough to disregard for all practical purposes, such as measuring voltages across 1.4-volt filaments?

(2) What effect, if any, do fuses already incorporated in instruments by the manufacturer have on the accuracy of readings? If compensation features are provided for the effect of these internal fuses, cannot this feature be provided for externally attached fuses?

[Name Withheld]

By B. F. McNAMEE, Altadena, Calif.

WHEN fusing an instrument, we should consider any possible effect of the fuse on calibration. To minimize any such effect, we should choose the lowest resistance fuse which will protect the instrument. This usually means the highest current rating which will do the job. Most instruments will stand an overload of at least 2 to 6 times their full-scale current continuously.

A 5000-ohms-per-volt voltmeter has a full-scale current of 1/5000 ampere, and there seems to be no fuse manufactured with this rating. But a fuse rated at 1/1000 ampere, which is 5 times the full-scale current, will undoubtedly protect this instrument against damage. If the overload should be several times the fuse rating, the fuse will blow in such a short time (a few microseconds) that the pointer will scarcely start to move, or the coil of the instrument scarcely change its temperature, before the current is shut off.

Change in Calibration of Voltmeters

Let R_V represent the ohms-per-volt, and V represent the number of volts full scale. Then the resistance of the instrument is VR_V, and the error (expressed in percent) introduced by adding a fuse of resistance R_F is:

$$\frac{R_F \times 100}{VR_V + R_F}$$

Thus a 500-ohm fuse added to a voltmeter of 5000 ohms-per-volt, and 10 volts full-scale, would introduce an error of

$$\frac{500 \times 100}{(10 \times 5000) + 500}$$

or approximately 1%.

Thus the voltmeter would read 1% low.

The only compensation that can be provided is internal. Some instruments have a magnetic shunt which can be moved, but on a multirange instrument this will correct only one range. The correct remedy is to reduce the series resistance of the instrument by an amount equal to the fuse resistance. But it will often be found that the error is negligible in an instrument used for general purposes.

Change in Calibration of Ammeters

In an ammeter the addition of a fuse has no effect on the calibration, but the resistance of the fuse does affect the circuit in the same way that the resistance of the instrument itself affects the circuit, by making the current less than it was before either the instrument or fuse was inserted in the circuit. So if the instrument and fuse are permanently connected in the circuit, there is no error, since their resistances are part of the normal resistance of the circuit.

Comparisons of Force-balance and Position-balance Control Mechanisms

By W. B. HEINZ, Consulting Engineer, Cochrane Corporation, Philadelphia, Pa.

IN an automatic controller the measuring means responds to a change in a measured variable and produces a corresponding change in a position or a force (or their electrical equivalents). Most proportional controllers "follow up" the measuring response by a balancing change in another position or force. Thus controllers can be classified as "position-balance" devices and "force-balance" devices.

Fig. 1 is a schematic diagram of a position-balance mechanism. A position change x moves a baffle about a frictionless pivot and makes a corresponding change in baffle position relative to a nozzle. The baffle on moving closer to the nozzle increases the pressure p_n which is applied behind a diaphragm or a bellows whose force is opposed by a spring. The pressure builds up until the changed position of the pivot has restored the baffle nearly to its initial position adjacent to the nozzle. A change in pivot *position* has then balanced the initiating change in *position* at x.

The output pressure p_n can be calibrated in terms of x or it can be utilized to operate a controlled valve by means of which x can be returned toward its initial position. The relationship between p_n and x is determined by the diaphragm area, the spring rate and the lever ratio. No force is required at x to create corresponding changes in p_n, since the pivot friction and the jet force at the nozzle are negligible. The output pressure p_n is substantially independent of the supply pressure p_s, because little more than an infinitesimal change in baffle position at the nozzle is required to overcome the effect of relatively large supply pressure changes.

In Fig. 2, position changes at x are initiated by changes in pressure p_x acting upon a spring-opposed diaphragm. The resulting change in nozzle pressure at p_n produces a corresponding change in position of the pivot carried by the follow-up element. This also is a position-balance mechanism, even though the initial position change results from a pressure change.

If we transfer the measuring means from the position shown in Fig. 2 and locate it directly opposite the follow-up element, as in Fig. 3, we can omit both springs. Slack diaphragms are used, possessing no spring characteristics of their own. Now we have a true force-balance mechanism. Since there is no spring anywhere in the system, the baffle can freely assume any position which may be required to make the follow-up pressure p_n exactly equal to the input pressure p_x. Thus the pressure p_n is completely independent of the supply pressure p_s. The relationship between p_n and p_x can be varied by utilizing unequal diaphragm areas; or, if the diaphragms be arranged to act on the lever at two different points, the slope of the p_n versus p_x curve can be varied by adjusting the lever ratio.

Fig. 4 illustrates schematically the basic mechanism of conventional indicating and recording controllers. The measuring means moves a pointer or a pen over a scale. Changes in position of the pointer are transmitted by frictionless linkage to a baffle whose position change creates a change in the nozzle pressure p_n. This pressure change is converted by the follow-up element into a corresponding position change which restores the baffle nearly to its initial position adjacent to the nozzle. Changes in the output pressure p_n operate a controlled valve which influences the measured variable in such a way as to return the pen or indicator toward the control point. This is a position-balance mechanism, in which position changes

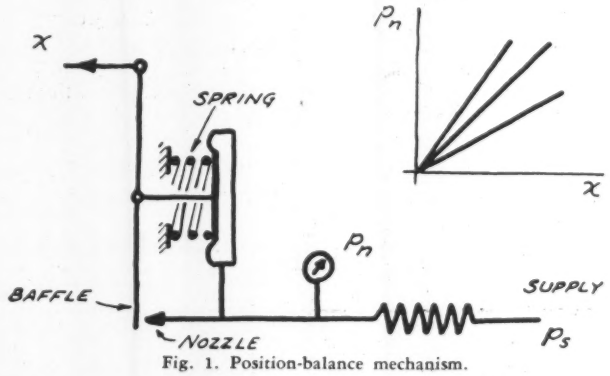

Fig. 1. Position-balance mechanism.

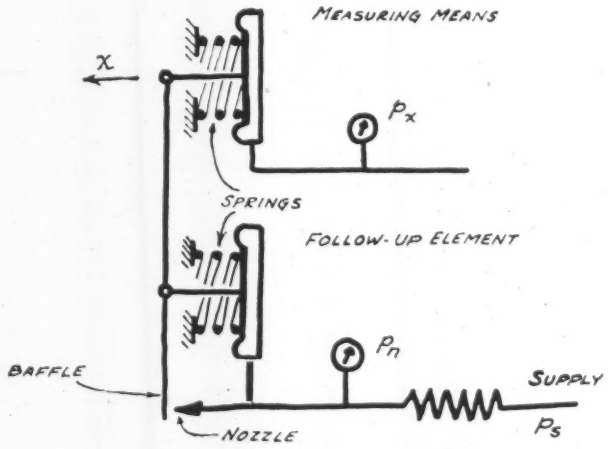

Fig. 2. Position-balance mechanism.

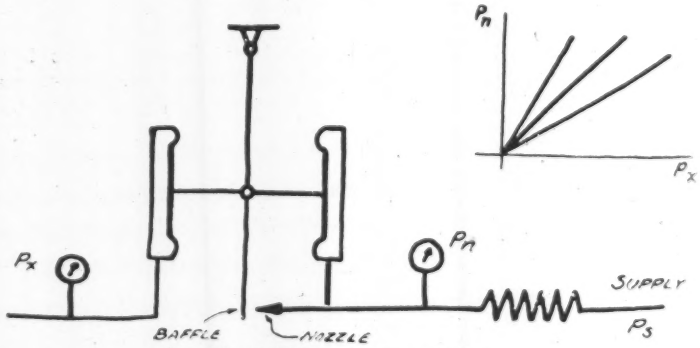

Fig. 3. Force-balance mechanism.

*Presented before the American Society for Measurement and Control, Hotel Roosevelt, Pittsburgh, Pa., May 28, 1945.

...the measuring means are balanced by corresponding position changes in the follow-up element. The spring shown in the figure is usually incorporated directly within the measuring means.

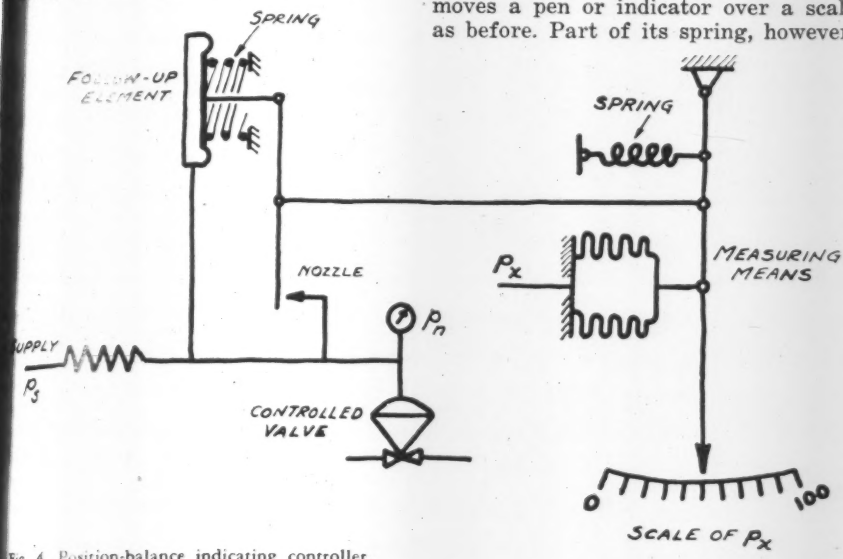

Fig. 4. Position-balance indicating controller.

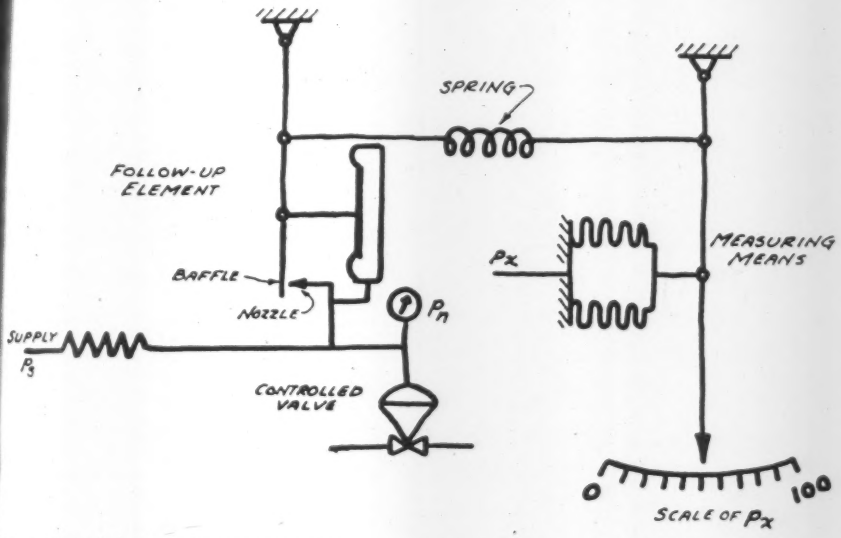

Fig. 5. Force-balance indicating controller.

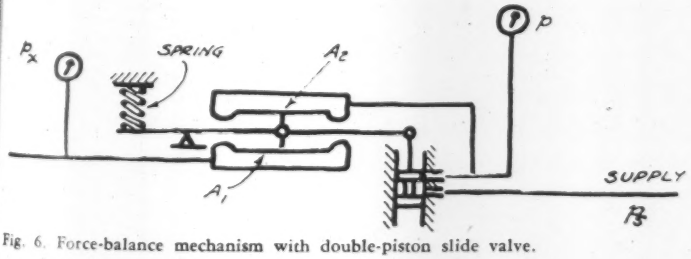

Fig. 6. Force-balance mechanism with double-piston slide valve.

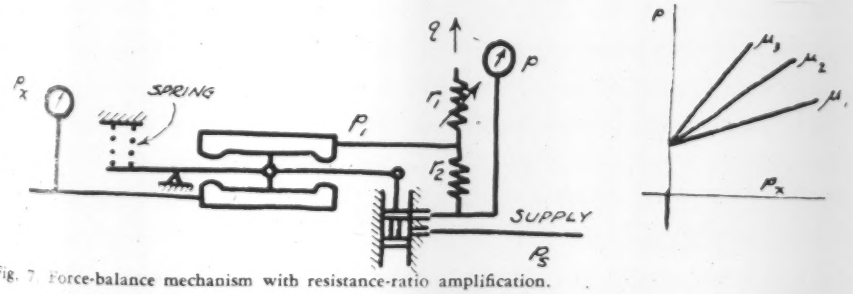

Fig. 7. Force-balance mechanism with resistance-ratio amplification.

A rearrangement converts the position-balance indicating controller of Fig. 4 into a force-balance indicating controller as shown schematically by Fig. 5. Here the measuring means moves a pen or indicator over a scale as before. Part of its spring, however, is now interposed between the indicator and the baffle in such manner that change in *position* of the measuring means is converted to a corresponding change in *force* on the baffle lever. An increase in this force increases the nozzle pressure until the force from the follow-up element once more balances the spring force. The pressure p_n is thus maintained proportional to the position of the measuring means and its indicating pointer. This pressure operates a controlled valve in a manner analogous to that of conventional position-balance instruments.

All conventional accessory features which make up commercial instruments are introduced into force-balance instruments by analogous but mechanically different arrangements. Several attractive advantages are obtained.

In all of the figures shown thus far, only one form of pilot valve has been shown—namely, a nozzle-baffle combination. Another common type of pilot valve is illustrated in Fig. 6. Here a double-piston slide valve admits air from the supply p_s to the output p when the valve moves upward. When the valve moves downward, the supply is closed off and the output p is vented to atmosphere above the piston. With the valve lever located in a horizontal position it is necessary to use a spring to balance the weight of the lever and diaphragm assembly. This spring has a low spring rate and it creates a negligible effect upon the balance of pressures behind the two diaphragms.

The relationship between p and p_x depends upon the force created by the spring and upon the amplification factor of the relay. When two diaphragms of equal area are directly opposed the amplification factor is unity, and a change in p_x will be balanced by an equal change in p. If A_1 be made larger than A_2, however, changes in p_x will create larger changes in p by the area ratio A_1/A_2. If two diaphragms of equal area be located at different points on the lever, changes in p_x will be amplified in p by the corresponding lever ratio. Thus the amplification factor in the arrangement of Fig. 6 depends either upon the area ratio or the lever ratio or upon a combination of both.

In addition to area-ratio and lever-ratio amplification of pressures, a third method is available—namely, resistance-ratio amplification. In Fig. 7 the follow-up pressure p_1 is taken from a tap between two resistances r_2 and r_1. The diaphragm areas being equal, changes in p_x must create equal changes in p_1 in order to maintain the force balance. Pressure p_1, however, is at all times equal to the product of resistance r_1 and the flow of air q which passes through the two resistances in series. In order to maintain the pressure p_1 between the two resistances, the pilot valve must create a pressure p which is equal to the sum of the two resistances multiplied by the same air flow, q. Consequently, p is greater than p_1 by the re-

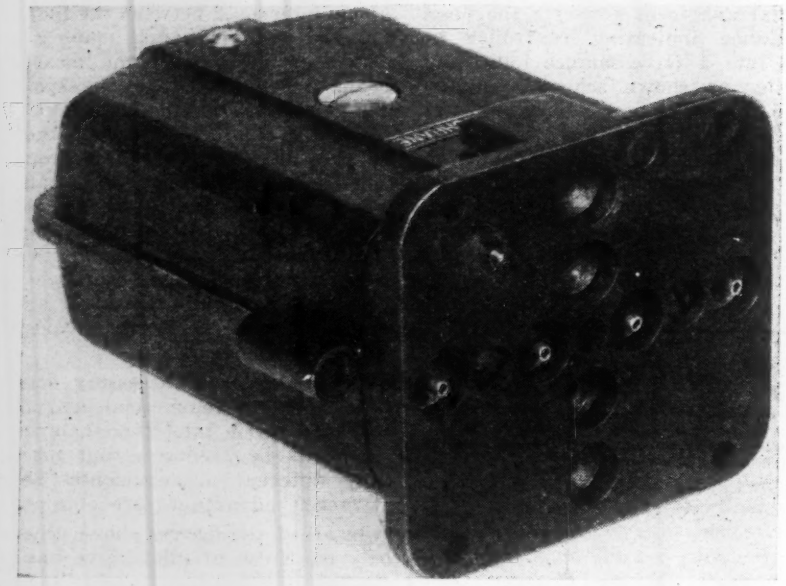

Fig. 8. Universal pneumatic relay assembly, shown nearly actual size.

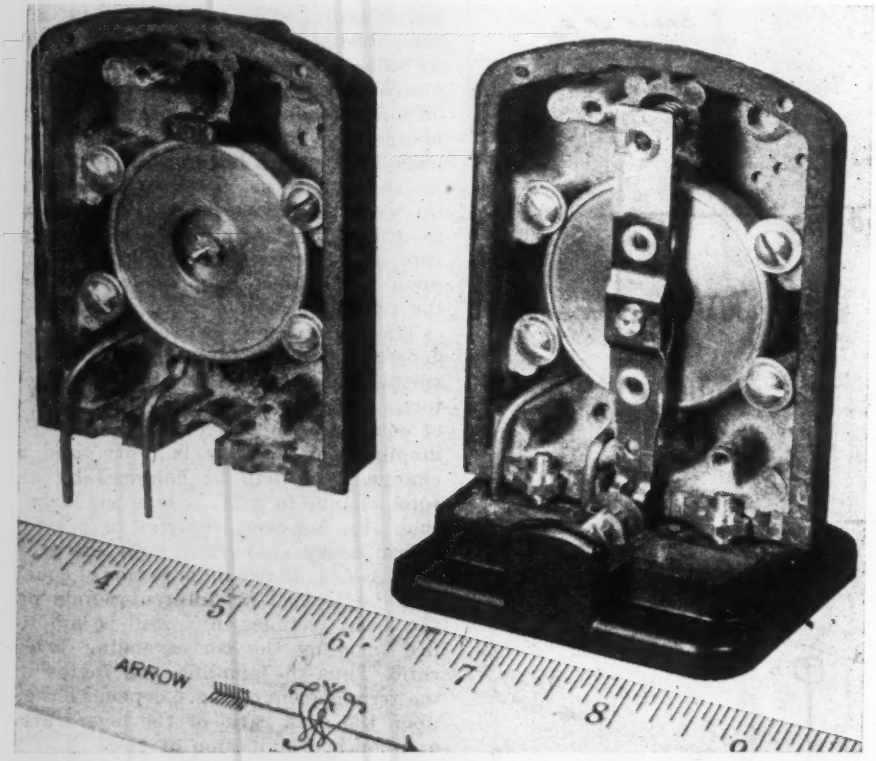

Fig. 9. The two halves of the universal pneumatic relay, showing the opposed capsules which utilize the force-balance principle.

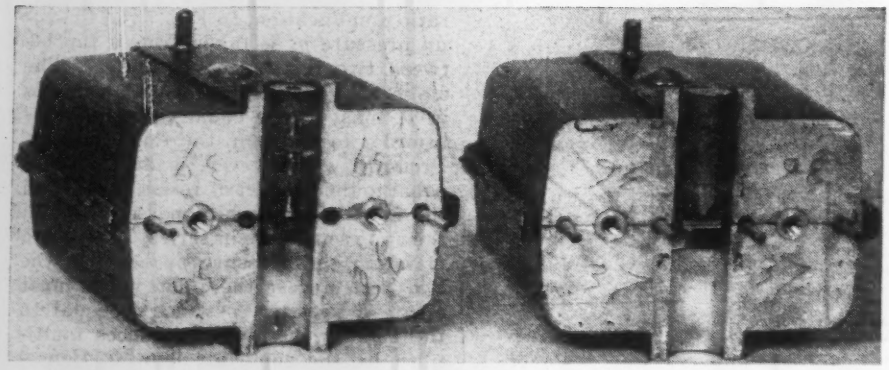

Fig. 10. Relay with piston type pilot valve.

Fig. 11. Relay with flapper type pilot valve.

sistance ratio $(r_1 + r_2)/r_1$. Since under steady-state conditions $p_1 = p_x$ it follows that the output pressure p is greater than the input pressure p_x by the amplification factor μ, where $\mu = (r_1 + r_2)/r_1$.

The amplification factor determines the slopes of curves of p vs. p_x, the amount of output pressure p at zero input pressure p_x depending upon the spring setting.

The amplification factor can be varied over a wide range by adjusting one or both of the resistances r_1 and r_2. Usually r_2 can be a fixed resistance and r_1 is adjusted by means of a needle valve functioning as r_1. In practice, the amplification factor ranges from unity to a maximum practicable value which approaches 1000.

The output of a first-stage amplifier can be connected to the input of a second stage. When so connected there is no feed-back from the second stage to the first, and even high amplification factors can be multiplied together without instability. If the individual amplification factors be adjusted to values of 500, for example, a two-stage combination will give an over-all amplification of $500 \times 500 = 250{,}000$. A change of one one-hundredth inch of water at input will produce an output change of 90 pounds per square inch.

A universal pneumatic relay has been developed, with the object of serving the maximum number of different applications. Fig. 8 shows an assembled unit. It is made up of two identical die-cast shells in each of which a diaphragm capsule is held by four screws (see Fig. 9). Interchangeable capsules contain one or two slack diaphragms, of various effective areas. A lever is held between the two halves by a spherical hub which is screwed to the center disks of the diaphragms. The lever rests upon two steel balls near one end, beyond which is a spring. The other end of the lever operates a pilot valve, as in Fig. 10, or serves as a baffle adjacent to a nozzle, as in Fig. 11. These parts are held together by sliding spring clips, ready for mounting on the relay base. The pilot valve is put into position with the valve center engaged by a fork on the end of the lever (see Fig. 9) and the base is put on over it. Two screws clamp the assembly together (Figs. 8, 10 and 11). Synthetic rubber washers are then slipped over the protruding tubes from the diaphragm capsules. The entire relay is now ready for installation on a panel, where protruding buttons compress the rubber washers axially and radially against the tubes. Four screws hold each relay in place, with as many as eight pneumatic connections made up at once.

When a nozzle-baffle pilot valve is to be used, a nozzle element replaces the slide valve body. The end of the lever adjacent to it then serves as the baffle (see Fig. 10).

In Fig. 12 is shown a typical relay (R) connected up for service as a pres-

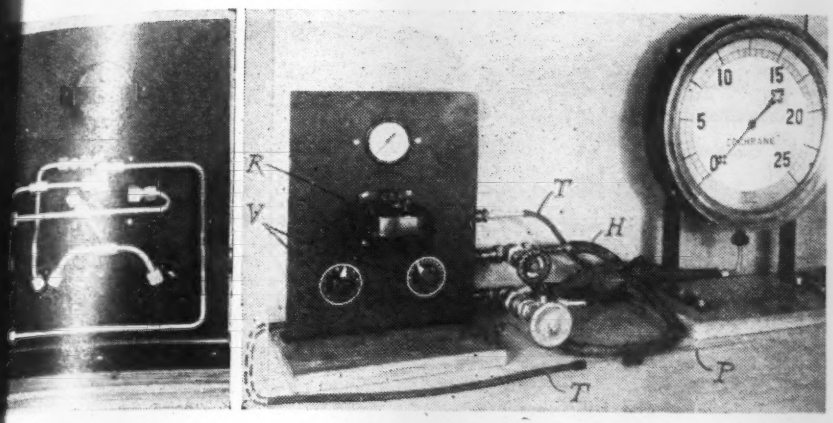

Fig. 12. Demonstration set-up in which a universal relay is used as a pressure amplifier.

re amplifier, its connections being the me as those of Fig. 7. The long rubber be T has one end connected to the out chamber and its other end, with glass pipette, is free for demonstra- n purposes. The output of the ampli- r is connected by means of the heavy se H to the pressure gage which is librated directly in pounds per square ch. The amplification factor is adjust- le by means of the two needle valves which constitute the r_1 and r_2 re- stances. The compressed-air supply rom a cylinder not shown) is through

[*Demonstration.* — "I now hold the ass pipette several inches from my outh and blow on it. . . . The momen- ry reading of the pressure gage shows at either a new world's record for man lung pressure has been set, or at the amplification factor is much reater than unity. Now I pass the tube mong members in the first few rows. . . Now I increase the amplification ctor: don't blow too hard! . . . Now I ecrease the amplification factor. . . . hat's the matter, my friend? Have ou no breath at all? . . . Now, again ncreasing the amplification factor, I mmerse the glass pipette to a depth of bout a tenth of an inch in this glass of water, and clamp it there while I adjust the amplification to make the gage read 10 lbs./in.^{2}. Note that the reading is steady. Finally, I vary the depth of immersion, slowly at first, then more quickly. The response is not as fast as that of an engine indicator, because the gage itself has a certain amount of inertia, but this demonstration brings out the fact that the resistances are analogous to pure electrical resistances: they do not slow down the action as does the combination of resistance and capacitance in, for example, a welding timer."]

An interesting application of the universal relay is illustrated in Fig. 13, which shows a circuit for the pneumatic transmission of float position in a rotameter. A stainless steel tube is used in place of the conventional guide rod inside the float. Within the stainless steel tube a glass tube is located, suitable gasketing being used to prevent air flow between the glass tube and the stainless. The glass tube has a precision tapered bore much like that of any rotameter tube. A steel ball is rolled up and down inside the glass tube by permanent magnets within the rotameter float. The resistance to air flow past the ball thus varies with the float position.

Two universal relays coöperate to function as a pressure controller maintaining constant pressure below the ball. The first one is assembled with a nozzle and baffle, the nozzle pressure being amplified by the second relay as required to create above a pneumatic resistance r_5 whatever pressure be required to maintain the pressure below the ball at the control point. This pressure p is indicated on any suitable gage, which can be calibrated directly in terms of flow through the rotameter.

In an indicating transmitter which will be ready for post-war sale, the components of this circuit are assembled in the form shown by Fig. 14. The

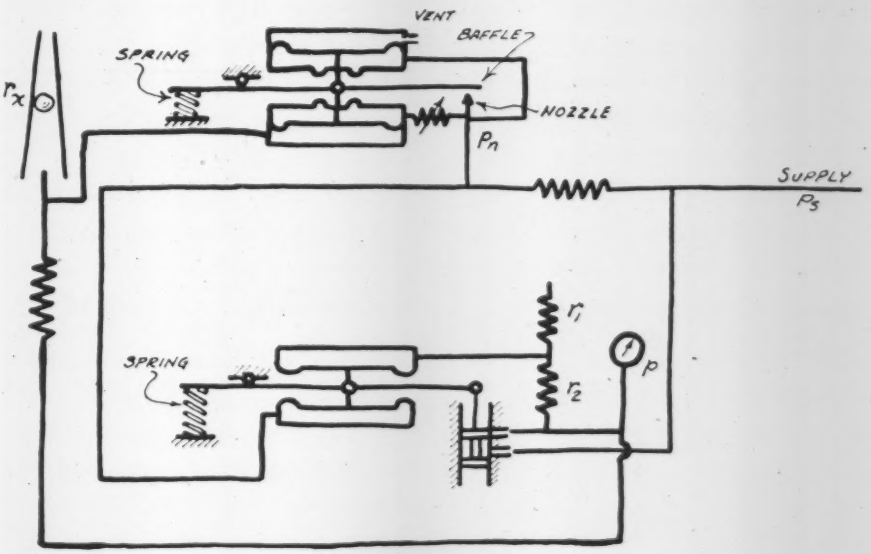

Fig. 13. Rotameter transmission.

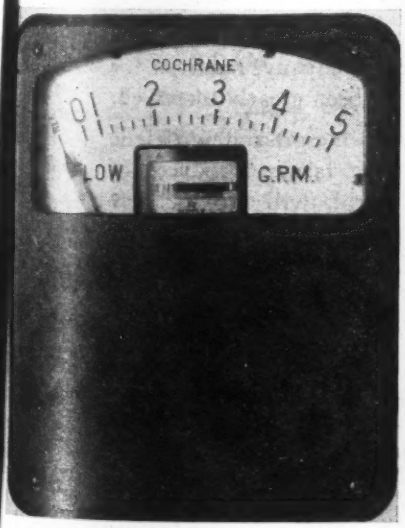

Fig. 14. Indicating transmitter.

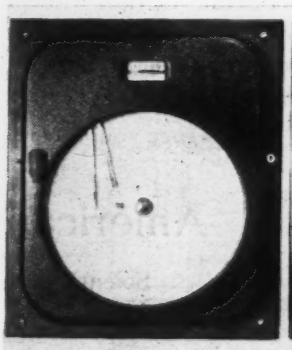

Fig. 15.

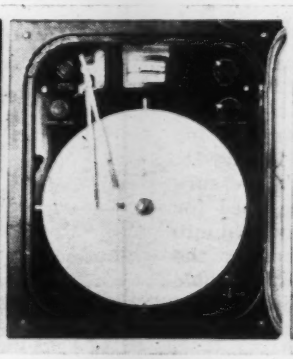

Fig. 16.

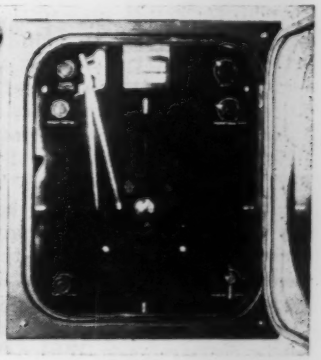

Fig. 17.

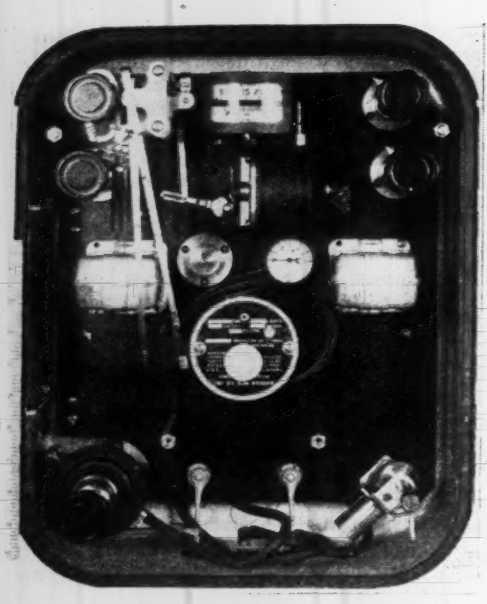

Fig. 18.

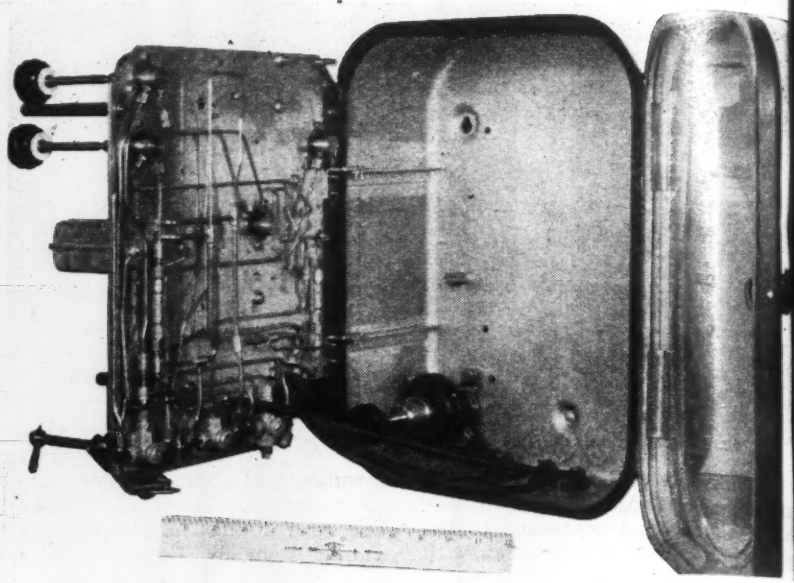

Fig. 19.

instrument includes a bold-faced flow indicating scale for use at or near the rotameter location, depending upon installation and service considerations. For example, when a completely-steel-encased rotameter is used for high-pressure or hazardous service, the indicating

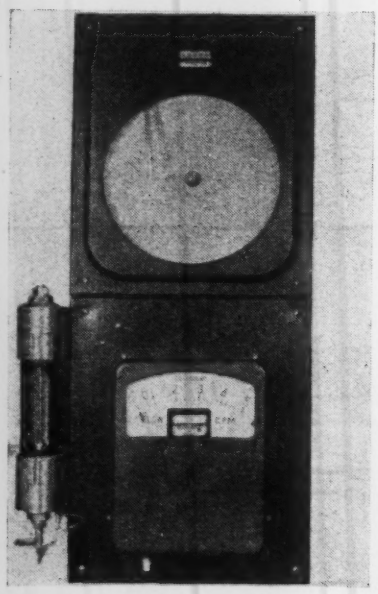

Fig. 20.

transmitter can be used to read the flow at the point of measurement. The output pressure of the transmitter can be connected remotely to additional indicators or to a recorder-controller, if desired.

A post-war recorder-controller for general service is illustrated in Fig. 15. This instrument is basically a pressure recorder-controller. It can be used for any variable which can be converted into corresponding pressure, either by the measuring means itself or by suitable pneumatic transmission. The instrument utilizes the force-balance principle already described. When the door is opened the instrument presents a conventional appearance, as shown by Fig. 16. The chart has been removed in Fig. 17. Removing the chart plate (see Fig. 18) displays the working assembly which is characterized by the absence of intricate mechanisms. The force-balance principle obviates the need of position-balance links and levers. Two of the universal relays are mounted on the panel. Access to the pneumatic circuit connections is provided by swinging the chassis outward as shown in Fig. 19. In view of the fact that these instruments cannot yet be offered for sale, detailed descriptions of their special mechanical features would be premature.

Finally, there is shown a photograph (Fig. 20) of a demonstration panel assembly comprising a rotameter equipped with the ball and tube for pneumatic transmission, its associated indicating transmitter and its recorder-controller

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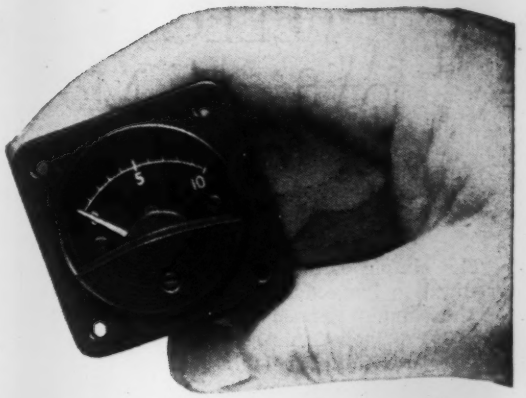

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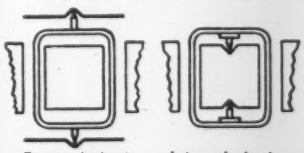

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ELECTRIC GAGING METHODS
for Strain, Movement, Pressure and Vibration

By HOWARD C. ROBERTS, Research Staff, Association of American Railroads, Chicago, Ill.

XI. POTENTIOMETER CIRCUITS.

§1. Direct-current Potentiometers.

The simple direct-current potentiometer circuit (usually credited to Poggendorff) is the prototype from which most of the commonly-used potentiometers have been developed. Fig. 171A shows this circuit in its simplest form.

The potentiometer is in principle a device by which an unknown potential can be balanced against a known one, with equality indicated by a sensitive galvanometer. Its accuracy therefore depends upon the accuracy of the standard source of electromotive force—and also upon the accuracy with which the comparison can be made—and its sensitivity depends upon the delicacy of the balancing procedure, which is dependent upon the sensitivity of the galvanometer and upon the manner of comparison.

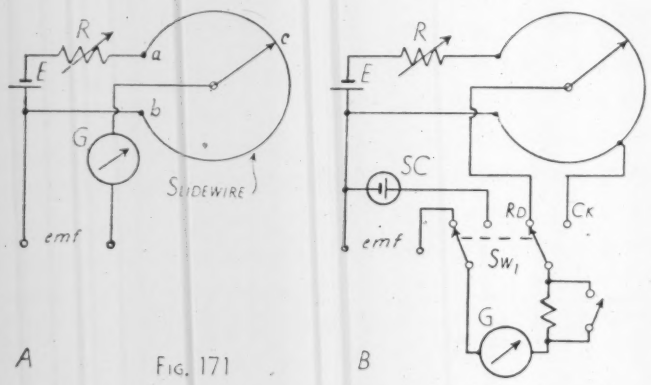


FIG. 171

In Fig. 171A only the bare essentials for a potentiometer circuit are shown. A slide-wire (circular) is connected in series with a source of electric current E and a regulating rheostat R; to one end of this slide-wire and to the moving contact upon it is connected a circuit containing a source of electromotive force and a sensitive galvanometer G. The circuit is "standardized" before use by applying a known electromotive force from a standard cell at the potential terminals and adjusting the circuit until the galvanometer shows no deflection; this indicates that the potential drop along the slide-wire from point a to point b is equal to the electromotive force from the standard cell. If then an unknown potential is applied at the *emf* terminals, and the galvanometer is found to show no deflection when the slider is at point c, the ratio of the known to the unknown potential is equal to the ratio of the distance ab to the distance ac. (The wire is assumed to be homogeneous.) If the current through the slide-wire is adjusted to a suitable value and the wire then fitted with a suitable scale, the instrument then becomes direct-reading. The actual value of the resistance of the slide-wire is of little consequence; the important thing is the potential drop along it.

The same circuit with two added features is shown in Fig. 171B. A switch *Sw 1* has been installed to facilitate standardization; it replaces the unknown emf. with the standard cell, and simultaneously connects the moving contact to the proper point along the length of the slide-wire. To standardize the circuit it is necessary only to move this switch to the *Check* position and adjust the rheostat until the galvanometer shows no deflection. To operate, the switch is placed in the *Read* position, reconnecting the unknown potential. A second switch is provided for shorting out a high resistance in the galvanometer circuit to facilitate final balancing. This high resistance protects both galvanometer and standard cell during preliminary adjustment.

The limiting factor in sensitivity and accuracy of this simple circuit (apart from homogeneity of wire and other constructional factors) is the fineness of subdivision of the resistance element—the slide-wire. Accuracy as high as one part in 1000 with a simple slide-wire of convenient length is a little difficult to attain, because of uncertainty of setting of the slider, and non-uniformity of the wire. There are, however, three widely-used methods for improving the subdivision of the graduated resistance element: they are the Crompton tapped-resistor method, the Varley vernier and the Rayleigh-Weston substitution method.*

In most instruments of moderate precision the Crompton tapped-resistance principle is used. It is an extension of the simple slide-wire, formed by adding fixed resistors in series with the slide-wire, and connecting as many of these sections as are needed to accommodate a measurement. Fig. 172 illustrates the manner of connection. Each step on the tapped resistor has a definite value of resistance; the slide-wire usually has a slightly greater resistance than the separate steps, so that it is never necessary to balance just at the end of the wire. Many instruments employ fixed steps of 0.1 volt, with the slide-wire range encompassing 0.11 volt.

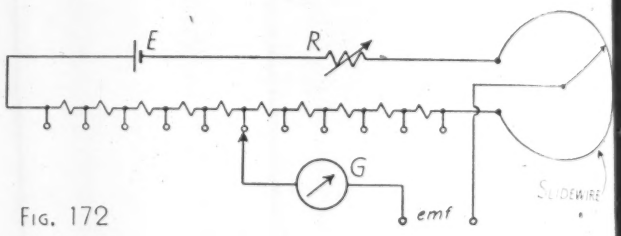


FIG. 172

The Varley vernier is one of the best and also most convenient of the devices for subdividing a resistance element. It employs tapped resistors arranged in decades, with a switching device so arranged that each decade is connected in parallel with two of the steps of the preceding decade. Each decade has eleven steps instead of ten; each decade has a total resistance equal to the resistance of two steps of the preceding decade. Thus when the second decade bridges two steps of the first decade, the effective resistance of those two steps is halved. A continuous slide-wire is often employed for the last dial.

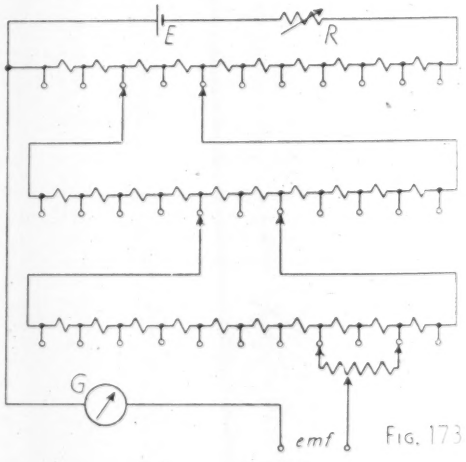


FIG. 173

A Varley vernier circuit of four decades, readable with ease to one part in 10,000, is shown in Fig. 173. M[illegible] dials

*This method is the one used in the Feussner potentiometer, and occasionally called by that name.

an be added to make the subdivision finer; the limit is reached when the contact resistances of the switching devices become comparable to the resistance of the decades. The Rayleigh-Weston substitution method makes use of the fact that the removal of an increment of resistance at one point and its insertion at another is equivalent to the movement of a slider. Mechanically, the device is composed of two resistance boxes coupled by means of linkages, so that as resistance is removed from one box it is added to the other. The total resistance is thus kept constant. The arrangement is indicated in Fig. 174; the mechanical coupling of the two variable-resistance units is indicated by the curved arrow. Fineness of subdivision depends upon the divisions of the resistance boxes.

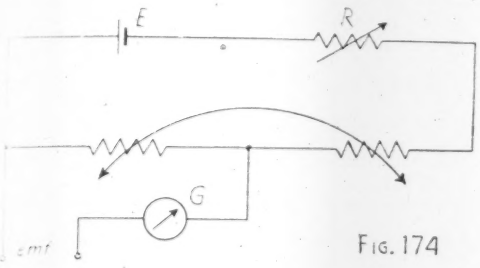


FIG. 174

Much the same precautions must be taken in the design of the potentiometer circuit as are required in the sensitive bridge circuit, if random errors from contact resistance and thermal emf's are to be avoided. The Diesselhorst potentiometer circuit embodies some exceptionally effective expedients in design; the circuit is capable of measurements down to a few hundredths of a microvolt. Physically, the circuit somewhat resembles a bridge circuit, as shown in

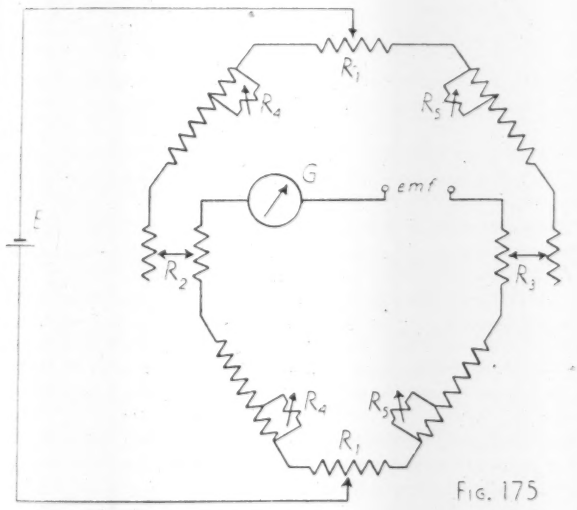


FIG. 175

Fig. 175. The unknown emf. and the galvanometer are placed in the detector diagonal of the circuit. The five decades are arranged in pairs and mechanically coupled together: R_1 indicates the two elements of the first decade, R_2 the second decade, and so on.

The special features of the Diesselhorst circuit may be seen from the figure. No switches appear in the galvanometer circuit, so no thermal emf's are introduced there, where they would cause the greatest error. The design of the circuit is such that the switching is performed in a closed circuit of constant resistance. Thermal emf's which may be produced are additive to the battery voltage rather than in the galvanometer circuit; their magnitude is never greater than a few parts in a million compared to the battery voltage. The only continuously-variable resistors (the others are tapped resistors fitted to multipoint switches in practice) are those in the fourth and fifth decades; these are shunts of rather high resistance applied to 1-ohm coils in the bridge-circuit arms. Any thermal emf's set up here circulate around a closed circuit of rather high resistance, and only that portion of the total potential drop which appears across the 1-ohm resistor is introduced into the circuit proper. Similarly, the contact resistances here are in series with a high value of resistance, and become items of no concern.

These design principles may be applied to many other measuring problems.

While the simple direct-current potentiometer already described depends upon the variation in magnitude of a resistance element carrying a constant current for providing an adjustable and accurate reference potential, it is equally possible to construct a potentiometer embodying a constant resistance but carrying a variable current. Here the current is the measure of the potential. The principle has been used in a number of instruments; one representative one will be described.

The circuit arrangement which acts as the potentiometer proper is drawn as Fig. 176A. This measuring circuit

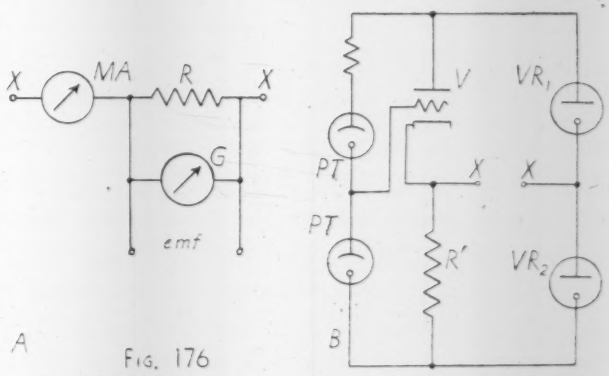


FIG. 176

consists of an accurate milliammeter MA in series with a fixed resistor of known value. The potential drop across this resistor may be made to assume any desired value by adjusting the current through it. (The source of current is not shown, but it must be applied at points XX.) The unknown electromotive force is applied to a sensitive galvanometer G which is also connected across the resistor R. Obviously if the galvanometer deflection produced by the unknown potential is brought back to zero by adjusting the current through R, the potential drop across R must be equal in magnitude and opposite in polarity to the unknown emf.

The Weston Electrical Instrument Company has employed this principle in the design of a self-balancing potentiometer instrument which affords an illustration of the use of the circuit as a control element. The basic circuit of the complete instrument is drawn in Fig. 176B. It constitutes a form of bridge circuit, with four impedance arms composed of an amplifying electron tube V, a fixed resistor R' and two constant-voltage regulator tubes VR_1 and VR_2. The control grid of the amplifier tube is kept within the operating range by the voltage divider at the left of the circuit—comprising a resistance element for adjustment and two photoelectric cells in series, equally illuminated.

It is a characteristic of this circuit that it will tend to adjust itself until no current flows through the bridge arm, which is broken at XX. This action may readily be understood when it is remembered that the control grid of V is maintained at a definite potential, so that any current which flows through the XX branch must either increase or decrease the current through R' and consequently the potential of the cathode of the electron tube V. This effectively alters the grid bias of the tube, allowing more or less current to flow through the tube, and thus restores equilibrium.

This circuit becomes a self-balancing potentiometer when the entire circuit of Fig. 176A is inserted at points XX in Fig. 176B. The galvanometer G must be installed in such a location that a beam of light reflected from its mirror impinges upon the two photoelectric tubes. The action then is as follows: If a potential is applied at the emf

terminals, the galvanometer will deflect, causing more light to strike one of the phototubes than the other. That tube will drop in resistance, and the potential of the control grid of V will be changed. Current will flow through the XX branch, producing a potential drop across R'; the polarity of the galvanometer is so adjusted that this potential drop tends to oppose the unknown emf. The galvanometer is thus returned toward its zero position, and the process continues until the galvanometer deflection is again zero. At this time, the potential drop across R is equal to the unknown potential, and its magnitude may be known from the magnitude of the current flowing through it. The instrument thus is a true self-balancing potentiometer, with the measured potential indicated on a rugged milliammeter. The range may be altered by altering the value of the resistance R and the full-scale range of the milliammeter MA: for example, if its range is 1 milliampere,, and the resistor R has a value of 100 ohms, the full scale range of the instrument will be 100 millivolts.

§2. Alternating Current Potentiometers.

The alternating-current potentiometer, like the alternating-current bridge, is more complicated than its direct-current counterpart. In measurements of alternating potentials, it is necessary to take cognizance of the phase angle of the potential. This concept need not be considered in measurements on steady-state currents or voltages.

The phase angle of the unknown potential may be measured either by rotating the phase of the comparison voltage until it coincides with the phase of the unknown—this requires a polar potentiometer—or by introducing two separate components in quadrature and adjusting their relative magnitudes until the unknown is accurately balanced. An instrument capable of doing this is called a coördinate potentiometer.

The Drysdale form of polar potentiometer is the one most commonly used. Its diagram is shown in Fig. 177. It closely resembles the simple d-c. potentiometer in its measuring circuit; in operation it must of course be energized with alternating current. The current circuit comprises a battery E, a regulating rheostat R, a slide-wire element, and a dynamometer current-measuring instrument D, all connected in series and forming the current circuit for direct

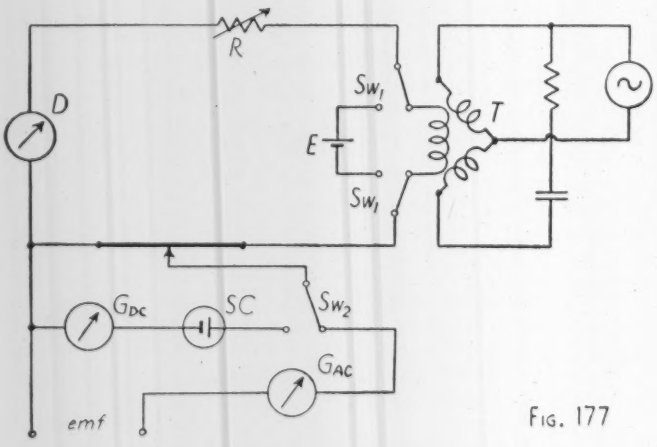


Fig. 177

current standardization; while by means of switch Sw a source of alternating current can be inserted in place of the battery for alternating current operation. The root-mean-square value of the alternating current can be set equal to the direct current used for standardization; the dynamometer-type instrument reads alike on either alternating or direct current. The source of the alternating current for operation is the phase-rotating transformer T, which contains two sets of primary coils, excited by currents in quadrature, and a single secondary, which can be mechnically rotated between the two primaries.

The potential circuit also may be connected in either of two possible arrangements, selected by switch Sw_2. One arrangement includes a standard cell SC and a galvanometer G_{DC} which is sensitive to direct current. This connection is the one used for standardization. The other connection introduces the unknown a-c magnitude and a galvanometer sensitive to alternating current, indicated by G_{AC}. It is customary to standardize the instrument on direct current, noting the indication of the dynamometer-type instrument, then to replace the battery by the a-c. source, re-adjusting R to give the same current through the slide-wire. The instrument then is direct-reading, potential magnitudes are indicated by slide-wire indications, phase angles by the indications of the rotatable transformer.

The operating principle of the coördinate potentiometer is exemplified in the Larsen instrument, which has perhaps the simplest circuit employed in such instruments; this

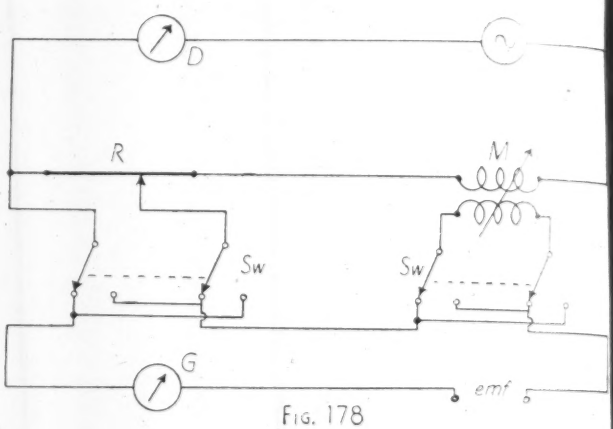


Fig. 178

circuit appears as Fig. 178. The current circuit includes a dynamometer-type current-measuring instrument G, a voltage-dividing resistor R, and a variable mutual inductance M. After the circuit has been standardized, an in-phase component is taken off through the voltage-dividing resistor and a quadrature component through the mutual inductance. These components are added together (since the elements are connected in series) and their sum is compared in the potential circuit to the unknown. An a-c. galvanometer is used as the detecting instrument. Reversing switches Sw change the phase of either component by 180° when necessary.

A device which can be most effectively used with the d-c. potentiometer, making it usable in a-c. measurements and especially in harmonic analysis, is the Joubert contact-making device. This method can be employed satisfactorily in measurements upon wave-forms so distorted as to be quite unmanageable with the ordinary a-c potentiometer.

The Joubert contactor is a cam-operated switch, driven by a synchronous motor connected on the line supplying the unknown alternating potential. At each revolution of the motor, it makes a momentary contact at the same point on the a-c. cycle, and since it is placed in series with

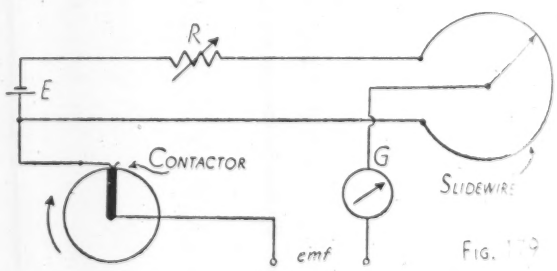


Fig. 179

the potential circuit of a d-c. potentiometer, it affords a measurement of the instantaneous potential at that point in time. The phase position of the contactor may be altered, and other potential readings taken at as many other points

s may be desired. The entire cycle may be mapped out in detail. The instrument, including the potentiometer, is sometimes called an ondograph. (French *onde* means wave.) Its circuit is given as Fig. 179.

§3. Standard Sources of Electromotive Force.

Potentiometer circuits are designed to compare unknown potentials to known ones; there must be available known standards of potential for comparison.

For d-c. measurements, the standard electrolytic cell is almost universally used. This standard cell is a carefully made voltaic battery, having a low temperature coefficient of potential, a long life, and a nearly-constant output potential. Standard cells should be carefully handled; they can be damaged by freezing, overheating, or by placing too low a resistance across their terminals. Most standard cells cannot supply more than about one microampere of current without damage.

Accurately-known potentials may also be produced by causing a known current to flow through a known resistance, and taking the resulting potential drop. (See Fig. 176.) This system is often employed with a-c. potentiometers, using a dynamometer-type current-measuring instrument, which reads alike on direct currents and on root-mean-squared alternating current values.

No chemical a-c. standard cell is available, but a thermal converter has been developed by which it is possible to compare effective values of alternating and direct currents to a satisfactory degree of accuracy for most measure-

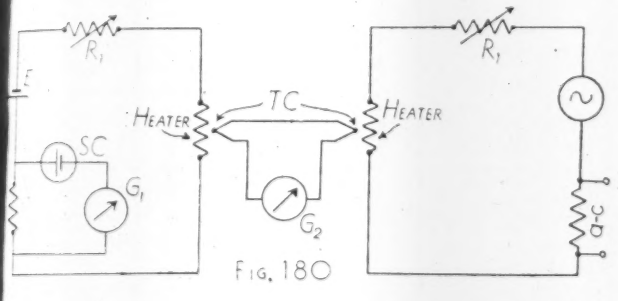


Fig. 180

ments. Fig. 180 indicates its mode of construction. Two similar heating elements are provided, one heated by direct and the other by alternating current. A standard cell *SC* and a galvanometer G_1 are connected across a known resistance so that the direct current may be easily and accurately standardized. The alternating current is adjusted until its heating ability is equal to that of the direct current; this is indicated when the outputs of the two opposed thermocouples, *TC*, cause no deflection of galvanometer G_2. A known alternating potential is then available across the known resistance R_2, at the terminals marked *a-c*.

At low frequencies, and with current of good wave-form, a well-made dynamometer-type instrument may be set to a specific value to an accuracy of better than 0.25 per-cent; at frequencies above perhaps 5000 cycles per second, or with alternating currents of poor wave-form, this thermal converter can be more effectively employed.

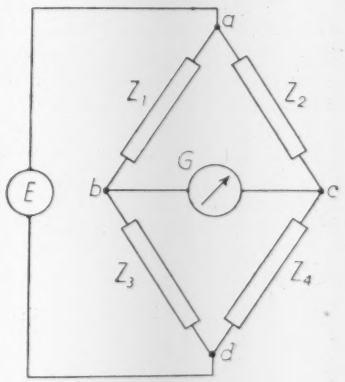
XII. INDICATING AND DETECTING INSTRUMENTS.

§1. General.

The detecting instrument employed with any bridge or potentiometer circuit has as its primary function the indication of the balance condition of the circuit. Satisfactory fulfillment of this condition requires that the instrument possess suitable characteristics as regards sensitivity, stability, and accuracy; uniform response to varying frequencies is also required if the circuit is used in any dynamic measurement.

Detecting (and indicating) instruments* may be grouped broadly into two classes: (1) those involving amplification, and therefore drawing little or no energy from the measuring circuit; and (2) those not employing amplification, and consequently drawing energy from the circuit. The difference is a fundamental one, and concerns the design of the circuit and its use. Present-day gaging practice employs large numbers of amplifying systems; electronic amplification provides increased sensitivity easily and inexpensively. Non-amplifying systems, for satisfactory operation, must be carefully designed, and the efficiency of amplifying systems may be increased if instruments having the proper characteristics are used. In order to facilitate the discussion of these instruments, the conditions affecting circuit sensitivity and their relation to the detecting instrument will be given.

In Fig. 181, a four-arm bridge circuit is drawn; between points *a* and *d* a potential *E* is connected, and an instrument, *G*, of infinitely high impedance is connected between



$$V = \frac{Z_2Z_3 - Z_1Z_4}{(Z_1+Z_3)(Z_2+Z_4)}E$$

$$\frac{\partial V}{\partial Z_4} = -\frac{Z_1}{(Z_1+Z_3)(Z_2+Z_4)}E$$

Fig. 181

points *b* and *c*. The exciting potential may be either alternating or direct, so long as the indicating instrument responds to the excitation. No current flows through the instrument *G*, and the potential across it may be written as indicated in the first equation. If the circuit is balanced (so that the potential between *b* and *c* is zero) then for an infinitesimal change in one circuit element the rate of change of output potential *V* may be written as indicated in the second equation. It is assumed that the balance equation is $Z_2Z_3 - Z_1Z_4 = 0$ and that the variable circuit element is Z_4.

It may be deduced from these equations that if adjacent circuit arms (Z_1 and Z_3, Z_2 and Z_4) are similar in type, the greatest circuit sensitivity obtains when they are equal in magnitude, and that in this condition the output potential equals the exciting potential *E* multiplied by one-fourth the percent change in Z_4. If adjacent arms are in quadrature, the maximum sensitivity occurs again when their magnitudes are equal, and is twice as great as when the arms have equal phase-angles. The proper configuration for the bridge circuit to provide maximum sensitivity is thus defined.

If the indicating instrument has a low impedance, and consequently draws appreciable current from the circuit, the relations describing the output become more complex. When the impedances of all circuit elements are known, the current flowing through the instrument may be computed by means of Thévenin's theorem.

It may be demonstrated that for greatest sensitivity in terms of current output the instrument, the four circuit arms, and the source of excitation should all have the same impedance. Adjustments may be made by means of transformers, or by the addition of reactance of the proper sign.

§2. Direct-current Galvanometers.

The moving-coil or d'Arsonval galvanometer is overwhelmingly the most popular of the detecting instruments employed to measure small unidirectional currents or potentials, or to indicate the balance condition of bridge

Continued on page 484

* An instrument is considered a detector if its function is to detect or indicate the *presence* of an unbalance current or potential; it is considered an indicating instrument if it shows the amount of unbalance. Physically they may be identical.

Standardized Testing of Components in Navy's Electronics Program

By Captain J. B. DOW, Director of Electronics, Bureau of Ships, U. S. Navy

NAVY electronic equipment is being used in every theater of war, where climatic and other conditions encountered are so severe that the establishment of simulating laboratory tests is an extremely difficult problem. A few of the general, severe conditions are as follows:

High temperature combined with high humidity is encountered in countries such as Malaya, Burma, the East Indies, and the Philippines where the rainfall is constantly heavy on most days during the wet season. The air temperature may rise by day to 40°C. and normally falls to about 25°C. at night, but is never less than 20°C. Consequently, the relative humidity is very high and frequently reaches saturation for considerable periods.

High temperature and low humidity conditions prevail in many regions and air temperatures as high as 58°C. occur during the day and a drop to freezing occurs at night. The relative humidity in these regions may be as low as 5 percent.

Subzero temperatures are encountered in Siberia, Alaska, Northern Europe, and the northern parts of Canada. Temperatures as low as −40°C. are frequently experienced. Temperatures of −55°C. are relatively common and −70°C. may occur in isolated regions. Equipment is not generally required by specifications to work below −40°C., but must not suffer any permanent ill effects through transport or storage at the lowest temperature met.

Components may be exposed to an air pressure of 120 mm. of mercury at an altitude of 42,000 feet. The rate of change of air pressure may be as high as 10 mm. of mercury per second. It should be remembered that equipment not designed for operation when airborne may have to be transported by air freight at high altitudes.

Air temperature at 42,000 feet is reasonably constant at about −55°C. The rate of temperature change experienced by descending aircraft may be as high as 5°C. per minute, but the actual rate of temperature change of apparatus will be lower, possibly 2°C. to 3°C. per minute.

Equipment is likely to suffer prolonged exposure to salt-laden atmosphere and spray from sea water.

Dust may be encountered as a cloud created a few feet above ground level by moving vehicles or as a dust storm created by strong winds which drive the particles to considerable heights and in all directions. The dust particles may be abrasive or hygroscopic.

In an atmosphere near saturation and in other favorable tropical conditions, fungus will start to form within a few days. Many destructive insects are also encountered in jungle regions. The effects of fungi and insects are very serious and call for much additional work on tropicalization of components and equipment.

All equipment must withstand, without serious reduction in performance or reliability, severe mechanical vibration, shocks, and rough handling.

SEVERE CLIMATIC AND SERVICE CONDITIONS

The experience gained in this war has shown that a high percentage of those components designed for domestic commercial service cannot withstand the extremely severe climatic and other conditions to which they are exposed either out-of-doors or under inadequate shelter during shipment, storage, and operation in forward areas. In addition, many refinements and advances in radio, radar and sonar design during the present war have imposed heavier demands upon the component designers and manufacturers for smaller, lighter, and more dependable types of components the need for which was not entirely realized even a few years ago. In fact, it is believed in many instances that improvements in the designs of components have not been carried out quickly enough to keep pace with equipment advances and, as a result, the problem of improving the usefulness, dependability, and ease of maintenance of equipment in the field is largely contingent upon improving the quality and performance of various necessary components rather than upon further refinements in the basic equipment designs.

THOROUGHGOING QUALIFICATION TESTING NEEDED

It is felt that improvement of the dependability of components and, hence, of complete equipments, is largely contingent upon more thoroughgoing and extensive qualification testing of components *per se*. In many instances, misapplication of components, with attendant high failure within equipment, can be traced directly to the fact that the limitations of the component with respect to electrical ratings, temperature, vibration, pressure, etc., had never been accurately established for the guidance of the equipment design engineer. In this connection the Navy is establishing at the Naval Research Laboratory a $1,000,000 component-testing laboratory supplied with the necessary measuring apparatus and technical personnel to pursue an active and continuing program for the improvement of components required in radio, radar, and sonar equipments. It is intended that this activity shall be maintained in peacetime on a large scale in order that the types of components suitable for Naval usage can be ascertained and made the subject of continuous improvement. The present qualification testing of components under Joint Army-Navy standard specifications, is being done on an appreciable scale at this laboratory and will increase as additional types of components are covered by approval JAN specifications.

The actual work of joint standardization of components has been carried on for over two and one-half years by the Bureau of Ships and Signal Corps, in collaboration with the American Standards Association, WPB, and representatives of industry, and has resulted in about forty published standard specifications with many more to follow in the future.

To better facilitate the work of component-part standardization, the Army-Navy Electronics Standards Agency, now quite generally known by its brief title ANESA, was established in December 1943 and was given the responsibility and authority for coördinating electronic equipment-component specifications to be used by both services. After drafting, the coördinated specifications are processed independently by the Bureau of Ships and Signal Corps through approved channels, and after industry and WPB have offered comments for consideration, a final approved draft is submitted to the Joint Army and Navy Committee on specifications for approval as a JAN specification.

Following issuance of the approved JAN specification, the laboratory facilities of the Signal Corps and of the Navy are pooled to carry out the qualification testing of components and materials submitted by prospective suppliers. Test reports resulting from qualification tests are reviewed by both services regardless of which service laboratory conducted the tests. Following review of the test reports, independent action is taken by each service to establish listings of approved manufacturers of standard components and materials. Action is presently being taken to work out a procedure by which Joint Army-Navy approval certificates can be issued.

Abstracted from an address, "The Navy Electronics Program and Some of Its Past, Present, and Future Problems," presented by Captain Dow at the Joint Session of the American Institute of Electrical Engineers and the Institute of Radio Engineers, New York, January 24, 1945. Reprinted by courtesy of the American Standards Association.

NEEDS OF NAVY IDENTIFIED WITH STANDARDIZATION

It is felt that the following urgent needs of the Navy flow directly from the need for standardization:

1. Replacement components in Navy yards and depots and in the field are more readily identified and, therefore, more readily usable among various types of Navy electronic equipments, since the standard components can be identified by standard markings, nomenclature, color coding, etc.

2. The workload imposed on field maintenance personnel, especially those inexperienced in maintaining equipment, is made less burdensome by virtue of the relatively smaller number of non-interchangeable components of each particular type which must be stocked, properly packed, housed, and correlated with the proper Navy electronic equipment.

3. The expanded use of standard components will reduce the vast numbers of components with respect to types, sizes, and ratings which must be dealt with in respect to improvements, testing, inspection, procurement, stock-upkeep, issue, and cataloguing, and hence reduce the manhours required for preparing necessary drawings, specifications, stock catalog numbers, and other clerical work.

4. The coördination of production among the various plants of equipment and component manufacturers, and control and scheduling of component deliveries to equipment manufacturers can be accomplished on a far better basis through the availability of standardized and coördinated components. The magnitude of this problem can be appreciated when I tell you that some thousand different plants and laboratories have been working under Army or Navy contracts in supplying electronic components and equipment.

In pointing out some of the shortcomings and difficulties of the component standardization program to date, there is no intention to lessen the appreciation of the work accomplished to date or to overlook the many impeding conditions imposed on such a program by the extremely heavy demands for components resulting from the wartime requirements of the Armed Services. The intent is rather to review the difficulties to date from the viewpoint of suggesting ways and means by which this initial start can be strengthened, expanded, and established on a more effective, firm, and continuing basis as soon as possible.

MORE ENGINEERS NEEDED ON STANDARDS

One of the more general difficulties has been the disinclination of many engineers both within the Government and within industry to become involved in the tedious, detailed, and relatively uninteresting work associated with the preparation of standards, with the result that a heavy workload has been imposed on a restricted group. It is felt that there should be a greater realization that the responsibility for component standardization must be assumed by a greater number of engineers who have a combined knowledge of the needs of the industry and Armed Services and of standardizing procedures.

Another difficulty experienced in that phase of component standardization having to do with the establishment of performance requirements is the tendency on the part of a relatively small portion of industry to question and heavily discount the necessity for some of the stringent and detailed requirements stipulated by the Armed Services. It is not claimed that the Services are in every case 100 percent correct in asking for certain tight and detailed requirements. However, by virtue of living with and having the responsibility for correcting failures in the field under conditions in the field, the Armed Services do have knowledge of the need for special performance requirements.

> "It is felt that improvement of the dependability of components and, hence, of complete equipments, is largely contingent upon more thoroughgoing and extensive qualification testing of components *per se*. In many instances, misapplication of components, with attendant high failure within equipment, can be traced directly to the fact that the limitations of the component with respect to electrical ratings, temperature, vibration, pressure, etc., had never been accurately established for the guidance of the equipment design engineer. In this connection the Navy is establishing at the Naval Research Laboratory a $1,000,000 component-testing laboratory supplied with the necessary measuring apparatus and technical personnel to pursue an active and continuing program for the improvement of components required in radio, radar and sonar equipments. It is intended that this activity shall be maintained in peacetime on a large scale."

In the past, and even at present, the advantages of standard JAN specifications are being mitigated by requests for waivers from the required tests. Such waivers in whatever form granted, and if allowed to grow, rapidly reduce the value of standard specifications to an ineffectual level. In the last analysis, the effectiveness of any good standard is largely contingent upon all interested activities voluntarily making every effort toward its adoption and application as a desirable instrument to implement mass production and simplify maintenance problems. Requests for waivers should be made only in cases of the highest urgency.

EARLY SELECTION OF STANDARD COMPONENTS WOULD HELP

The production of dependable and easily maintained equipment, with the least component complexity, is largely contingent upon the early selection and application by the equipment design engineer of standard approved items for the various required components during the conception, research, and development phases. Research personnel and development engineers working on the early stages of equipment development are far too prone to use nonstandard components in their early experiments and, far too often, the resulting mechanical and electrical problems left to the final design engineers are so formidable that many non-standard components are left in the equipment as it is finally delivered, and the great benefits of component standardization are lost.

Another important consideration in overcoming a past weakness in the standardization program is that of selecting three or more geographical locations where adequate accommodations can be established for standardization meetings.

While the prime effort of component standardization must be directed toward problems of immediate urgency in advancing the present and future activities of this global war, it is also important that we start plans for a postwar standardization program.

The Armed Services sincerely hope that the component standardization achieved during the war will not be shelved in the postwar period, but will be expanded and improved. A restricted but significant start has been made.

It is not my intent here to attempt to outline the structure for a postwar standardization association, but, rather, to emphasize from the experience gained in this war the importance to the Armed Services and industry, jointly, with the engineering societies, of realizing the need and assuming the responsibility for a coöperative program of component standardization. The reorderings, delays, waste of material, waste of shipping and storage space, excessive purchases of spare parts, added costs, and many other undesirable conditions arising from the use of nonstandardized items must be vastly reduced. Taken collectively, these undesirable conditions have probably already cost the Navy $100,000,000 in this war.

What has been accomplished in standardization under war conditions will be lost again in the years of peace to follow unless industry continues to understand and give full support to solution of the problems of the services. If financial help is needed, I feel that the Navy alone should and would contribute $1,000,000 per year, or whatever amount was needed, to support a virile and effective electronics standardization association, which, in coöperation with the services during the years of peace, would anticipate and remedy the conditions which I have mentioned.

IMMEDIATELY after Pearl Harbor, the airlines gave up half their planes to a hard-pressed Uncle Sam. Then, as the tempo of war picked up and the nation demanded speed and more speed, the men and women who fly our sky routes turned in one of the greatest jobs in transportation history.

Working against terrific handicaps in shortage of equipment, the airlines carried more and more and more. Passengers and freight increased. The load ratio went from 59% in 1941 to an "impossible" 90% in 1944. Planes put in more and more hours per day . . . until many were flying eighteen out of twenty-four, and only perpetual overhaul kept them going.

Through three long, tough years, maintenance crews fought the battle of the monkey wrench to keep America's precious, time-saving handful of commercial ships in the air and on schedule. Month in and month out pilots flew them sweet and careful . . . nursed them for speed . . . hung up new safety records . . . delivered vital goods and people to keep the war effort running at an ever faster pace.

Today, with relief in sight, the airlines are pointing the way for postwar America and the world. Against high wartime operating costs, they recently announced rate cuts. Airline route mileage in U. S. is at an all-time high of 62,937 miles. Freight carried is nearly four times

APPLICATIONS OPERATING PRINCIPLES INSTALLATION MAINTENANCE

Aviation Instruments

Navigation Automatic-piloting Power plant Automatic-landing Aerological
Communication Flight-testing Production Instrument-testing

Vol. IV, No. 7 M. F. Béhar, Editor July 1945

Electricity Outlet System Saves Time at ATSC Instrument Repair Installation

By Colonel WILLIAM TURNBULL, Commanding Officer, San Bernardino ATSC

AN unusual outlet system for furnishing different kinds of electricity used in testing instruments is in operation in the instrument repair department of the San Bernardino (Calif.) Air Technical Service Command, one of the main Air Forces maintenance and supply centers which the Air Technical Service Command has scattered in a network extending throughout the United States and overseas.

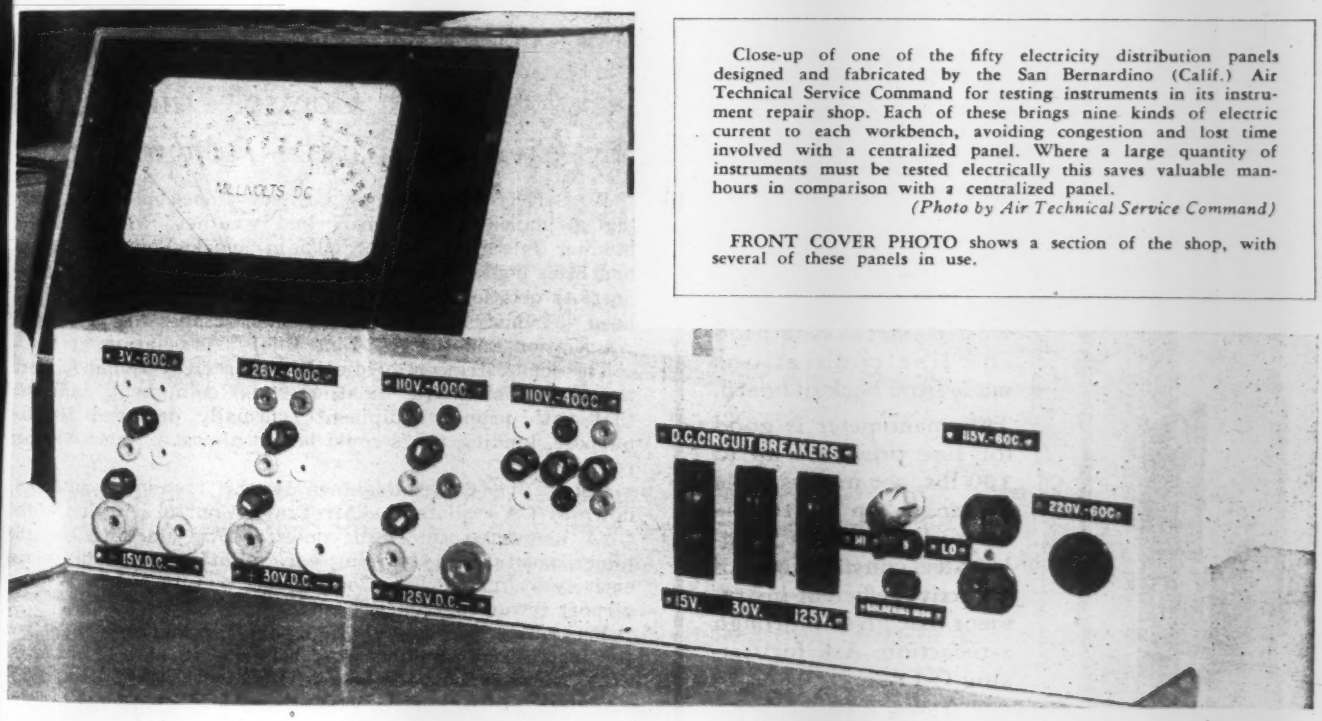
Fifty individual panels, one for each workbench, replace the customary centralized panel. This permits employees to test different instruments without getting up from their benches and enables them all to use the same electric power supply simultaneously. The system was designed, fabricated and installed by the California installation.

Three motor-generator sets convert the 110-volt alternating current of the plant to direct current of different voltages. Aircraft inverters are utilized to change the direct current to different alternating-current frequencies and voltages. The nine currents thus supplied are: 30-volt 60-cycle, 26-volt 400-cycle, 110-volt 400-cycle (single-phase), 110-volt 400-cycle (three phase), 15-, 30- and 125-volt direct current, 115-volt 60-cycle and 220-volt 60 cycle.

Electric power is distributed from a central source to the individual panels by means of concealed four-inch gutter conduits, for protection of employees.

More than one hundred different instruments are tested with the panels. The majority of these are aircraft panel instruments. The electricity distributors are used also for testing radio instruments and calibrating test instruments.

To eliminate the possibility of damaging the instruments, panel outlets have different colors, matching the coloring of test plugs. The system is designed to provide a margin of safety against damage from short circuits or overloads, with fuse margins below the instrument standard margins. All circuits are fused, with the exception of heavy-current and direct-current outlets, which have circuit breakers.



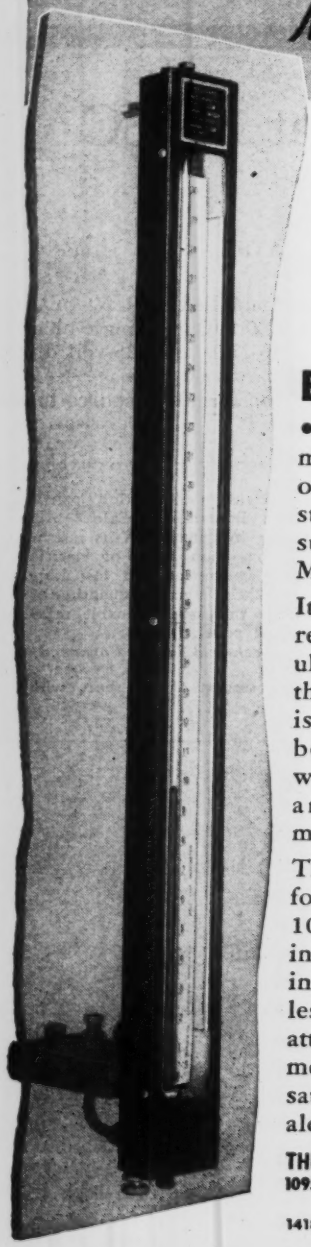
Close-up of one of the fifty electricity distribution panels designed and fabricated by the San Bernardino (Calif.) Air Technical Service Command for testing instruments in its instrument repair shop. Each of these brings nine kinds of electric current to each workbench, avoiding congestion and lost time involved with a centralized panel. Where a large quantity of instruments must be tested electrically this saves valuable man-hours in comparison with a centralized panel.

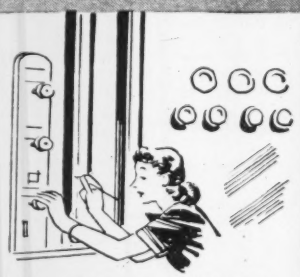
(Photo by Air Technical Service Command)

FRONT COVER PHOTO shows a section of the shop, with several of these panels in use.

A WELL TYPE MANOMETER

. . . for Front-of-Board Mounting





BY MERIAM

• To meet the needs for mounting a manometer on the front of an instrument board, we are supplying this popular Model A-324-FB.

It is the well type, direct reading unit. The rectangular well detaches from the body, instrument body is mounted on front of board, the manometer well then reassembled and line connections made from back of board.

This manometer is good for line pressures up to 100 lbs. per in. Available in ranges up to 100″—in steel, brass, or stainless steel construction. An attractive, efficient instrument that gives thorough satisfaction. Ask for Catalog C-11.

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Throttle-control-system Gages Save 92% to 99% of Synchronizing Man-hours

BALTIMORE—A simple method for setting the throttle systems from the pedestal to the engines in planes has been made possible through the use of a series of new gages designed and constructed at The Glenn L. Martin Co. These gages have proved particularly valuable in simplifying maintenance work on planes in the field when a carburetor change proved necessary.

The new tools are small, calibrated gages, one for each carburetor, and an additional one for the engine throttle control levers in the cockpit. In the case of Martin Marauders, the set for field work consists of one for each of two carburetors and one for the control lever. They are calibrated to synchronize both engines at idle r.p.m.; 1000 r.p.m; 1900 r.p.m.; and at 40° and 50° manifold pressure, which are the important operating settings for the type of engines used in the Marauders.

The tools are extremely simple to use. The throttle levers are locked at one of the desired check points as marked on the pedestal gage. Then the rods and cables are adjusted to the comparable setting on the gage at the carburetor. This results in a standard set-up for all planes of a single type and makes it relatively easy to adjust the throttle system anytime a test or check is necessary.

The new tools have proved particularly valuable as test-time savers for engines now can be synchronized in approximately thirty minutes. Before they were put into use, the work took from one-half to three days to complete. In addition the new gages eliminate all guess-work on the part of mechanics when adjustments are made.

New Approach Control Demonstrated by Civil Aeronautics Administration

WASHINGTON—A new CAA-developed method of landing airplanes in extremely bad weather, which reduced landing time by more than 50% in "blacked-out pilot" tests, has been demonstrated to key officials of the Air Transport Association and the Air Line Pilots' Association. been demonstrated to key officials of the Air Transport Association and the Air Line Pilots' Association.

The demonstration, held at Washington National Airport, using only standard, existing radio equipment, indicated that with proper equipment especially designed for the purpose, landing times could be cut almost to good-weather routine.

Using five CAA airplanes in the transport category, flown by CAA pilots, the Air Traffic Control Division of the CAA simulated zero-zero conditions by blacking out the pilot's position and forcing each pilot to guide his plane entirely by instrument. Control was maintained by regular airport tower controllers.

Previously, the best average time for bringing in planes for instrument landings was between 10 and 12 minutes. CCA Airways officials believe that with the planned installation of static-free VHF (very-high-frequency) radio equipment, "blind" landing time can be cut still further. However, the demonstration used only existing equipment, and it is the new *method* which is responsible for the saving in time.

Under the new method, arriving airplanes are "stacked up" for holding procedure over a fan marker about ten miles from the airport. This differs from the current method of holding over the range station itself, which is usually located immediately adjacent to the airport.

By starting descent further out, from the fan marker, the pilot can approach on the range leg in a straight-in approach, pass over the range station at final approach altitude, and make a normal let-down.

For demonstration purposes at Washington, the Mt.

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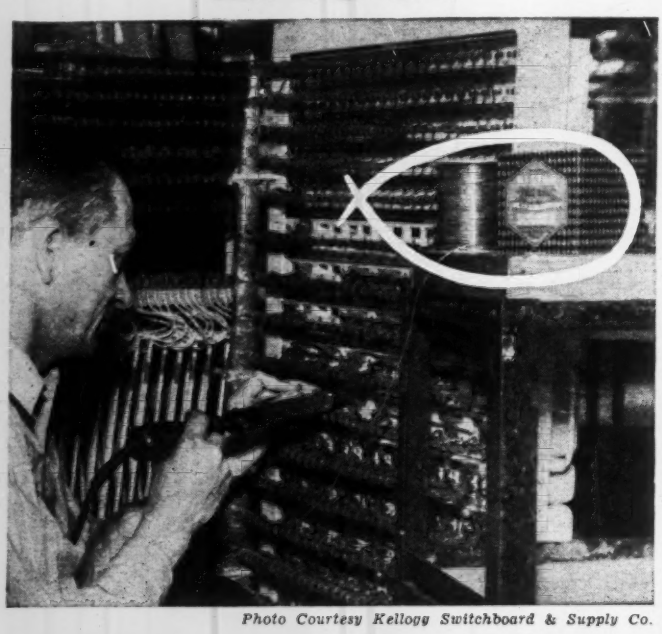

Photo Courtesy Kellogg Switchboard & Supply Co.

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Vernon fan marker, located 8.2 miles from national Airport, was used for a holding point. The pilots chosen for the test are all competent instrument pilots, but not engaged in instrument flying continually nor as much as airline pilots. During the test, the planes were stacked in the usual thousand-foot separation pile with the lowest at 2000, the high man at 6000.

Each pilot in the approach sequence was given approximately five minutes advance notice of the time he should leave the Mt. Vernon fan marker, and was allowed one minute error either way. The pilots then arranged to leave Mt. Vernon, at the proper time, headed for the range station by varying their holding paths and without further instructions from the controller.

The second aircraft was instructed to descend from 3000 to 2000 immediately after the first plane had left 2000. Headed to the Airport, each plane was stepped down as the one below left its level. This can be done with surprising speed. During the only test in which this feature was timed, the plane at 6000 feet was descending 95 seconds after the plane at 2000 had passed Mt. Vernon and started his approach. During the 95 second each plane between had been instructed to descend and had advised the controller that he had vacated his altitude.

In normal heavy-traffic conditions, Airway Traffic Control would be feeding a continuous stream into the top of the stack, and a cascade of planes would be flowing down at all times, passing the fan marker 3 to 5 minutes apart.

Control instructions are brief and simple:

CONTROLLER—Army 096 depart Mt. Vernon 1054, make straight-in approach, maintain 2000 until advised. (Given at 1048)
PILOT—Roger, Army 096.

or

CONTROLLER—Eastern 32 descend to 2000 immediately, report leaving 3000.
PILOT—Eastern 32 leaving 3000.

Except in unusual conditions, or when unforeseen troubles develop, these two instructions control the entire routine up to the final landing approach.

The CAA believes that this demonstration, operated on the Washington range station "in competition" with a normal flow of traffic conversation, showed that even better results can be obtained in the future by allocating one VHF frequency to Approach Control. VHF would eliminate static troubles which garble conversation in bad weather, and clearing a frequency for approach control would eliminate competing conversations.

In the near future the CAA will make a public demonstration at Indianapolis using VHF equipment.

Robot Cameraman Permits Aerial Photography at Night

SCHENECTADY, N. Y.—A photoelectric control that automatically synchronizes a new type shutter for aircraft cameras with the bursting of a flash bomb, thus enabling military observers to photograph from high altitudes and at night the destruction caused by their explosives, has been developed through the collaboration of General Electric and The Folmer Graflex Corporation.

Use of this control permits the camera to take advantage of the peak illumination of the bomb by beginning an exposure in approx. 0.01 sec. after the flash bursts. After the desired exposure time has elapsed, the control closes the shutter of its own accord. At the same time the camera automatically rewinds the film and gets ready for another picture, thereby saving the observer precious minutes and permitting another picture to be taken automatically as soon as the next bomb explodes.

Brains of this robot control is a photocell that acts on the light impulse coming from the bomb. When the flash explodes, the photocell picks up a light impulse, amplifies it and transforms it into a current to which the shutter responds in less than 0.002 sec. By using this combination, an aerial camera, otherwise of use for daylight photography only, can be converted into a camera capable of taking night

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In our research and development departments, we have produced equipment for the inspection of the cathode-ray tube, as well as equipment in which the cathode-ray tube has served as a measuring device.

Already, the cathode-ray tube figures importantly in the postwar projects of many manufacturers. For information regarding the adaptability of the cathode-ray tube to your own manufacturing processes, write to:

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photographs of the ground in great enough detail to permit the closest military study.

Small enough to fit into a hat bag and weighing only 9 lbs., this robot device was designed especially for use on reconnaissance planes and bombers. Both photocell control and shutter are shock-proof in construction. When in use, the control operates on three billionths of a watt—about the equivalent of the energy spent when a human hair falls a tenth of an inch.

Sperry's New Flying Lab

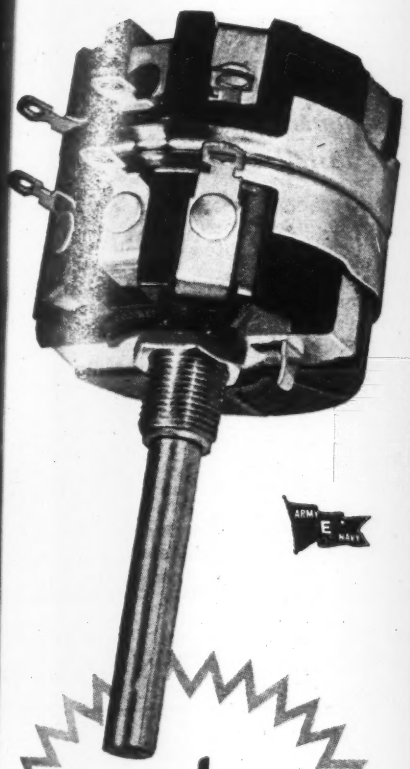
In this new photo, research engineers of the Sperry Gyroscope Company, Inc., are seen in a specially-equipped B-24 Liberator flying lab, making instrument tests and performance records under actual flying conditions. They rigidly test all new flight instruments, such as the Attitude Gyro and Gyrosyn Compass, recent Sperry developments to provide pilots with accurate indications of the attitude and direction of their planes.

Base for Flying Labs Founded by General Electric

SCHENECTADY, N. Y.—A base for flying laboratories designed to speed through scientific tests new military and civilian aerial developments, such as the actual harnessing of jet engine and gas turbine power for new-type planes, will be established at Schenectady County Airport by General Electric Company, it was announced by D. C. Prince, vice president in charge of the General Engineering and Consulting Laboratory.

C. G. Talbot has been appointed manager of the new Flight Test Division of General Electric, which will have control of this test headquarters, where many new aerial advancements will receive their initial operations in flight. N. F. Frischhertz, now stationed in Brownsville, Texas, where General Electric has tested many aviation developments now being used by the Armed Forces, is the assistant manager.

Work on a big hangar and ground laboratory will begin immediately at the airport, Mr. Talbot said. This hangar and laboratory will be 160 feet wide, 180 feet deep, and 45 feet high in the center. Two floors of laboratories, work rooms and offices will run down one side. In front will be



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This is to remind our readers that *Instruments* pays $5 (or more*) for each shop kink or other time-saving and accuracy-promoting idea accepted for publication.

The following rules must be observed:

1. Type double-spaced on one side of paper. Author's name and address at top of first page (envelopes get lost!)
2. Diagrams must be in black ink (no blueprints). Lettering (if not made with aid of machine) may be soft-pencil, to be inked-in by *Instruments*.
3. Only professional-grade photos will be accepted (preferably 5 x 7 or 8 x 10 glossies).
4. Each contribution to describe ONE method or device. An author may send as many as he likes.
5. Mail all entries to Shop Kinks Dep't of *Instruments*, 1121 Wolfendale St., Pittsburgh 12, Pa.

*Five dollars is for textual entry accepted: a greater minimum is paid for accepted entries including drawings and photographs.

Share Your "Know-how"

a high control tower with all of the latest electronic and mechanical equipment.* It will be near the Saratoga Road, adjacent to the 5000-foot North-South runway.

"This testing base will be completed and in operation in the fall," said Mr. Talbot, who has been conducting flight tests for G-E since shortly after the war began. "It will put the actual flight test operations in close contact with top ranking engineers of the Company and research laboratory facilities. That is certain to speed many new developments into actual use on military and civilian planes.

"Based on the accomplishments of G-E engineers in swiftly developing many outstanding aerial devices and apparatus under wartime pressure, it is a virtual certainty that the test center at Schenectady Airport almost overnight will become known internationally as a flight laboratory."

Some of the General Electric developments already scheduled for flight laboratory tests are:

1. *Jet Engines and Gas Turbines:* Through design and development of the super G-E Jet, most powerful aircraft engine in the world, which drives the Lockheed P-80 faster than any other plane will fly, General Electric is far in the lead in this new field of motive power. It is considered a certainty that the time will come when tests in the use of these new high-powered engines will be on civilian planes. Then, under the new plan, Schenectady County Airport will be a world center of that type of jet and gas turbine flight tests.

2. *Armament:* Working out of final problems in flight operations of improved aerial gunnery systems and newly developed mechanical and electronic apparatus and devices in this field will be one of the primary purposes of the Flight Test Division. The proving of aerial armament developments in this way is a vital step into speeding them into production and action against the enemy.

3. *Autopilot:* Developments in automatic control units for both military and civilian aircraft will go through rigorous operational flights.

4. *Electronics:* Achievements in this field pertaining to aerial operations have been tremendous during the war, but most of them still are blanketed by military security. Tests along this line are certain to be carried forward on a comprehensive scale.

5. *Instruments:* The G-E instrument division, based pri-

*Editor's Note—What? no *electrical* equipment? . . . no optical equipment? . . . No doubt, stenog left words out!

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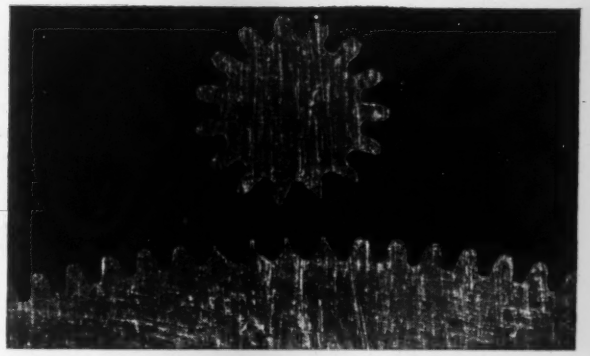
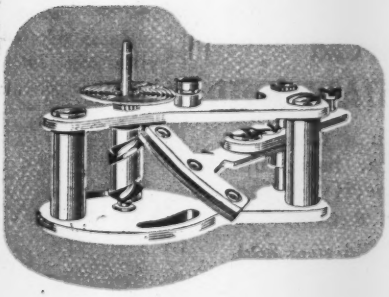


Here's what happened to the stainless steel gear teeth of a good conventional gauge movement after 500,000 cycles of operation at 1200 pressure pulsations per minute. In contrast — after 30,000,000 cycles, the cam facing of the *Helicoid movement* was merely burnished, and the accuracy of the Certified Gauge was unaffected. This was the result of a test made by an independent laboratory.



Only Certified Gauges are made with the Helicoid movement. This means there are no teeth to wear out or get sticky. The smooth rolling action of the Bakelite cam against the hard bronze roller practically eliminates wear.

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Brushes: Equipped with metal graphite brushes. Beryllium copper brush springs.

Governor: Furnished with a centrifugal governor to maintain constant speed over a voltage range of 25 to 30 volts.

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Modifications: Motors can be furnished with special shaft extensions, mounting arrangements, finishes, leads, etc.

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DEPARTMENT N-22 • RACINE, WISCONSIN

marily at West Lynn Works, Lynn, Mass., has developed outstanding instruments for airplane control during the war. This work is going forward steadily, and tests of the new developments of this kind will be made at the base here.

6. *Electrical Power Systems:* Power systems to drive numerous electric motors and other apparatus and to light cabins on huge transport planes of the future are being developed. These will graduate from tests at Schenectady Airport for use on those planes.

7. *Communications:* Many forward advances in the field of aerial communications already have been made by G-E engineers. Others are in progress.

8. *Power Apparatus:* Scores of types of motors, generators, transformers and the like, varying in size and design for specific jobs on various types of planes, are now being produced by General Electric. With the changes in the types of planes, many of these developments will be improved. Tests on the various units and power systems will be completed here before they are put into flight operations in civilian or military planes.

The broad field covered by G-E aviation developments make it certain that at various times planes of virtually all kinds will be in operation at Schenectady Airport. These might in a single day vary from advanced jet fighters to privately owned helicopters. Also, these tests will be made when conditions permit for civilian companies, as well as the armed forces.

The operation of flight test laboratories by General Electric began soon after the war started at LaGuardia Field, New York City. There tests were made on many advances now in use on AAF planes, including the B-29 Superfortress Central Control Gunnery System* and the pressurization of the B-29 cabins with turbosuperchargers that also fed air to the engines. American Airlines then was flying and servicing the laboratory planes for G.E.

The test center was moved to Brownsville, Texas, in March of 1944, and there G-E engineers got the first B-29 to be assigned to any manufacturing and development company. Pan American Airways have been flying and servicing the planes at Brownsville.

Some of the testing operations will continue at Brownsville, but the headquarters of the Flight Test Division will be in Schenectady as soon as the base here is completed.

*For full description see article by H. T. Hokanson and T. S. Lisberger, *Instruments*, Jan. 1945, pages 19, 20, 22, 24, 26.

G. I. Inventors Devise Means of Testing Gas-expansion Cylinders

WASHINGTON.—A couple of Air Service Command sergeants have licked a supply problem that all but had the logistics "chart-and-graph" experts crying into their India ink.

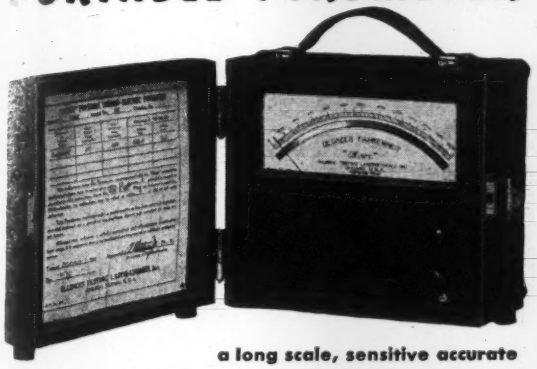
Working in the hydraulic department of an ACS depot in England, Sgt. Walter Halbert of Waco, Texas, and Staff Sgt. William Dunlap of Willows, California, found themselves faced with a critical shortage of temperature regulator valves, the kind needed to cool the hydraulic systems of P-38 Lightnings and P-51 Mustangs.

In the many demands placed on it by combat flying, the hydraulic system of a fighter plane often becomes overheated. Raising the quarter-ton landing gears during the take-off, pushing windflaps up into a four-mile a minute air-stream to power-dive—these are some of the things a hydraulic system does in flight.

When overheating threatens to foul the system, rising temperature forces a gas, housed in a cylinder about the size of a finger, to expand. The expansion sets a shaft into motion, opens a set of small doors, and lets in a stream of air. In about a minute, the hydraulic system is cooled to functioning temperature.

These temperature-control gas-expansion cylinders, a vital part of the whole cooling system, had to be replaced each time the hydraulic system was inspected. A brand new

Alnor type 1760 PORTABLE PYROMETER



a long scale, sensitive accurate portable pyrometer, ideal for laboratory and similar service.

Type 1760 Portable Pyrometer with the special thermocouples provided, affords extremely accurate temperature readings. Long mirror scale and knife edge pointer make accurate readings easy. High internal resistance allows moderate variation in thermocouple size, and length of connecting wire, without affecting accuracy. Internal automatic cold end compensator is standard equipment.

Type 1760 is available with single range and two range scale. Standard ranges from 0-300 deg. F. to 0-2500 deg. F. With rare metal thermocouple, range 0-3000 deg. F. Write for Bulletin 2416 with complete listings of all types.

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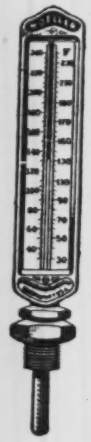

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one had to be installed because there was no way of testing the old cylinder, under anything even approximating the conditions at which it operates.

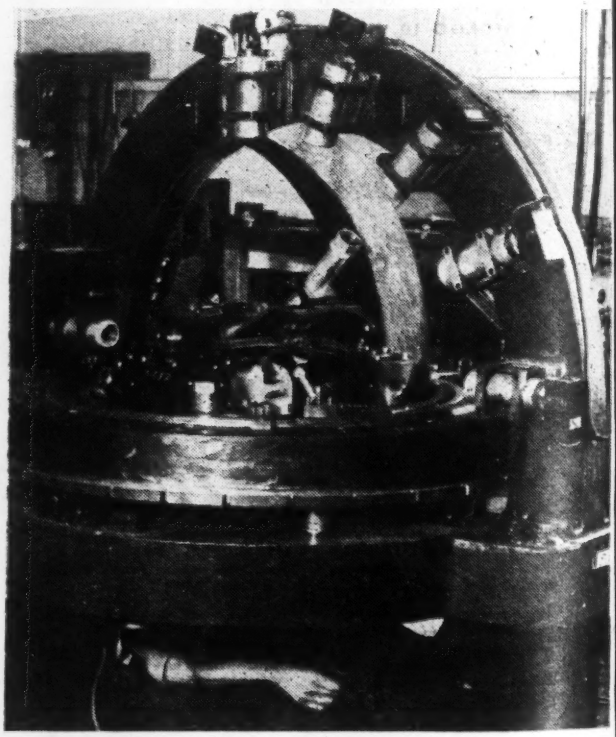
When the supply of new cylinders ran out, desperate maintenance technicians had to resort to a time-consuming trial-and-error process. An old cylinder was attached to the cooling unit. If it worked, good. If not, another cylinder had to be put in. And, if necessary, another, until they found one that worked.

Then Sgts. Halbert and Dunlap hit on a way to test the expansion cylinders and separate the serviceable ones from the others. They made use of an old oxygen pressure gage. When heat was applied to the gas in the cylinder it expanded, and its expansion could now be checked on this gage. A fast review of their high school physics and Halbert and Dunlap were able to figure out the coefficient of expansion for the gas, that is, just how much the gage hand had to move to indicate that the cylinder was in working order.

As a direct result of this process, their shop was soon able to supply front-line combat mechanics with the much needed cylinders. The two men have turned out hundreds of the chambers, every one of them going straight into a P-38 Lightning, or a P-51 Mustang, powerful fighting ships which gave such closely coördinated air support to Allied armies when they were driving through Germany.

Final Mechanical Test of B-29 Ring Sighting Station

SCHENECTADY, N. Y.—This technician at a General Electric plant sees nothing but trouble ahead for the Japs as she makes a series of tests of the B-29 ring sighting station, one of five control points in the Superfort's highly



protective gunnery system. By means of the precisely-located collimating telescopes, she measures the angular transmission and backlash between the line of sight and Selsyn generators used in the deadly armament system, and also the tracking accuracy of the line of sight in a vertical plane. [The remote-control gunnery system for the B-29, developed by G-E in coöperation with the AAF, was fully described by H. T. Hokanson and T. S. Lisberger in *Instruments*, Jan. 1945, pages 19, 20, 22, 24, 26.]

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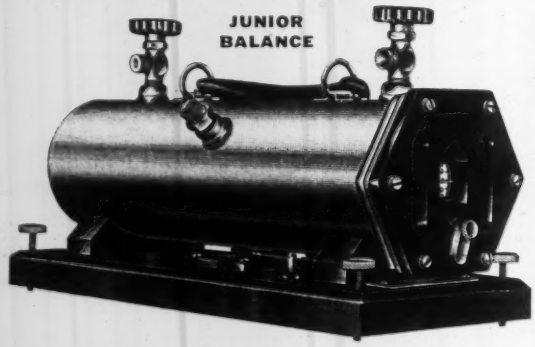

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ELECTRIC GAGING METHODS

Continued from page 465

or potentiometer circuits excited by direct current. The moving-magnet galvanometer—Kelvin or Broca type—was used extensively some years ago, and the moving conductor or Einthoven galvanometer (often called the string galvanometer) is still used for specialized applications. But in recent years improved designs and better materials have caused the moving-coil galvanometer to assume a commanding position.

The operating principle of the moving-coil instrument is a simple one; it is based on the fact that when an electric current flows through a conductor situated in a magnetic field, a mechanical force is produced, acting on the conductor at right angles to both magnetic field and the direction of the conductor. In Fig. 182 are sketched the essentials of the instrument. The moving coil (shown here as comprising 1½ turns) is suspended within the field of a permanent magnet, by means of the slender metallic suspension. Current is introduced into the coil through the taut upper suspension and the lower coiled suspension. At any time the force exerted on each unit length of wire in the coil will be proportional to the product of the current flowing through the wire and the intensity of the magnetic field. While the current flows *down* one side of the coil it must flow *up* the other, so that the forces produced are additive and cause rotation of the coil.

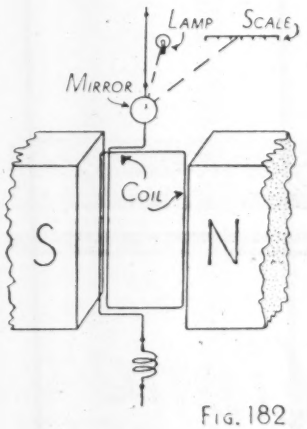


FIG. 182

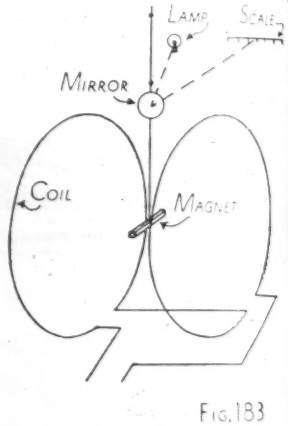


FIG. 183

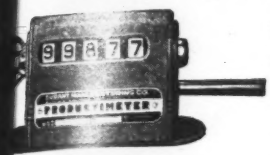
The restoring force against which this torque acts is supplied by the upper suspension, which is deformed by the coil rotation. The lower suspension often does not supply any restoring force at all.

The angular displacement of the coil may be indicated either by an attached pointer moving over a graduated scale, or by an optical system. In the drawing a light and a scale are indicated, with a small mirror attached to the moving coil. The more sensitive galvanometers usually employ optical systems; the less sensitive, more robust, portable galvanometers usually are fitted with light-weight pointers.

Instead of flexible suspensions, jewel bearings may be used to support the moving coil; in this mode of construction, the restoring force is supplied by hairsprings through which the current is conducted to the moving coil. In most instruments, too, a soft iron core is fixed within the moving coil but not attached to it, to increase the efficiency of the magnetic circuit.

The moving-magnet galvanometer operates in a manner which can be called the converse of the moving-coil operation; it employs a relatively large stationary coil, through which the unknown current flows, and has suspended within that coil a small magnetized needle—or assembly of needles—which is caused to rotate by the mechanical forces set up between the permanent magnetic field and the field of the current-carrying coil. Because of

No Production Let-up until *Total Victory!*



With the production machines of the nation humming on toward another Victory, still more pieces and parts must be counted . . . on some it will be revolutions . . . on others turning out materials, the count must be measured in feet or yards. Whatever it is, you can depend on

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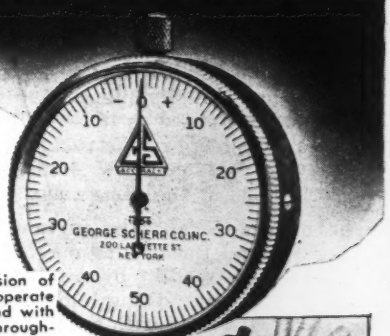

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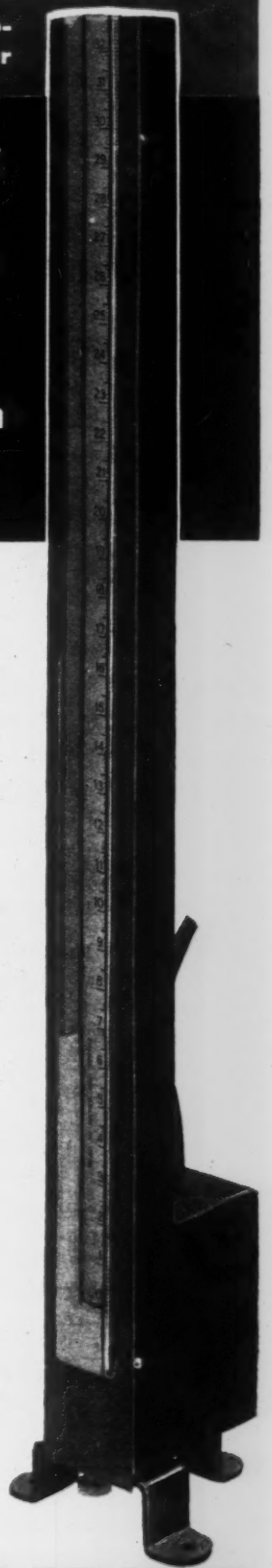

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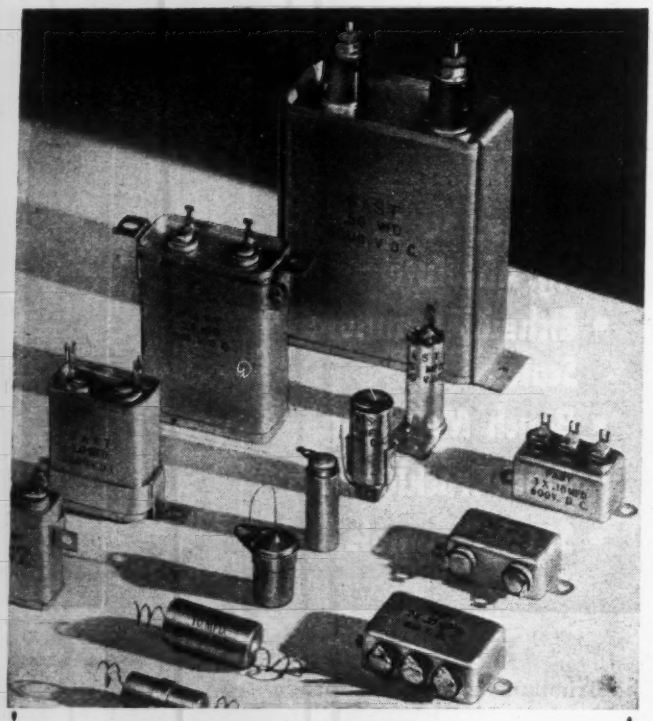

MEMO . . . *From:* FAST

***To:* DESIGNERS OF POSTWAR ELECTRONIC DEVICES**

Developments in electronic devices for war and post-war find ever broader application for FAST Capacitors.

Engineered and built by specialists, FAST Capacitors can be supplied to meet the most rigid requirements. Units are produced for operation at low or high temperatures and pressures (minus 50°F. to plus 190°F. and altitudes up to 40,000 feet) . . . Capacitors with good power factor (0.5% or less) and high insulation resistance . . . Units that have excellent stability over a wide range of temperatures and frequencies with relatively slight changes in capacity. Single units can be furnished in voltages up to 250,000. Phone or write for recommendations or other data—our entire organization is at your service.

When you think of Capacitors, think Fast

Capacitors for Electronic Instruments, Electron Microscopes, Laboratory Standards, Motion Picture Cameras and Projectors, Oscillographs, Oscilloscopes, Pressure Controls, Regulators, Relays, Scientific Instruments, Sound Recorders, Special Purpose Meters, Spectographs, Spectrophotometers, Temperature Controls, Timers, X-Ray Apparatus and many other Devices.

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the construction of the instrument, the magnetized need experiences all the movement. See Fig. 183.

The moving-conductor or string-type galvanometer al operates by virtue of a mechanical force produced by magnetic field acting on a wire carrying an electric cu rent. The instrument comprises a single stretched stra of fine wire, placed between the pole-pieces of a magne A current flowing through this filament causes a movemen to take place in a direction at right angles to both filame and magnetic field; it is customary to pierce holes throug

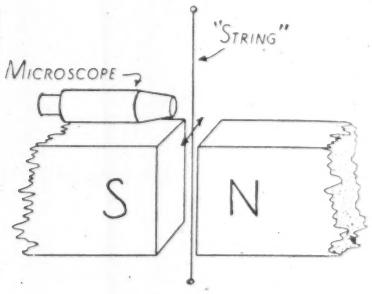


FIG. 184

the magnet pole-pieces to permit observation of the d flection of the stretched filament. The deflection may b read with a microscope, or by means of an optical syste which projects a greatly magnified image of the strin upon a graduated scale. The instrument is well suited multi-channel use, since several strings may be mounte close together in the same instrument, employing the sam magnetic field and the same optical system.

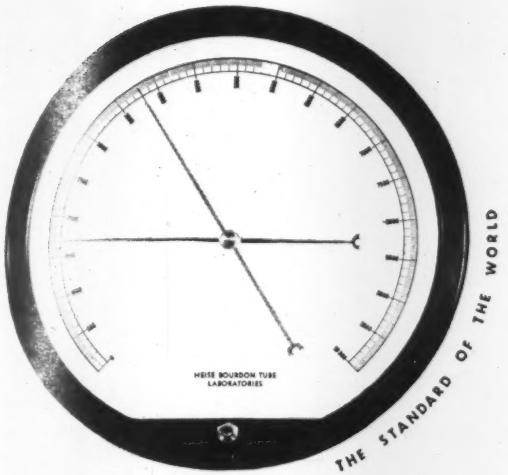
Each of these types of indicating instrument has i advantages; each is best suited to its own uses. For ge eral purposes, the moving-coil instrument is far more con venient than either of the other two. The string galvanom eter is not so conveniently used as either of the other, be cause of the need for the microscope or the projection sy tem; the projected image is not always easily observe The string galvanometer, moreover, cannot well be mad with high voltage sensitivity. The moving-magnet galva nometer, while far less convenient in use than the movin coil type, has the advantage that the space available fo the coil is not limited as it is in the moving-coil type; it therefore possible to construct moving-magnet galvanom eters having extremely low ohmic resistance and high cur rent sensitivity at the same time.

The impedance and the current sensitivity of both th moving-coil and the moving-magnet galvanometers may b adjusted quite readily by altering the number of turn in the coil or the strength of the magnet. An auxiliar magnet is often used with the moving-magnet galvanometer to adjust the restoring force to the desired value. With th string-type galvanometer, the range of adjustment cannot be made so great, but it is possible to change the dimen sions and the material of the stretched conducting filament and its tension within a limited range. The strength of th fixed magnetic field may also be altered within a wide range, either by applying a magnetic shunt to a permanent magnet or by adjusting the exciting current if an electro magnet is used.

It should also be recognized that any of these instru ments can be employed to measure varying currents, o even on alternating current measurements, within their *mechanical* limitations. It is obvious, of course, that an instrument having a long period (an extremely low natural frequency) cannot respond to rapid variations in current. Alternating-current instruments—especially those capable of delineating wave-forms—will be separately treated.

Electron-tube devices, either as d-c. instruments or as amplifying devices to increase the sensitivity of d-c. galvanometers, are only occasionally used.

To be continued



EVERY DAY we are shipping these precision pressure gauges to be used in place of dead weight testers. They are accurate, dependable and easy to read. Delivery—2 to 6 weeks.

RANGE FROM 0-25 lbs. to 0-10,000 lbs.

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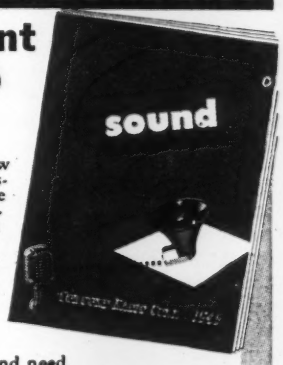

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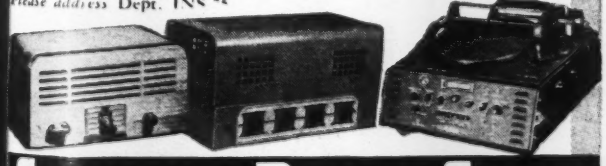

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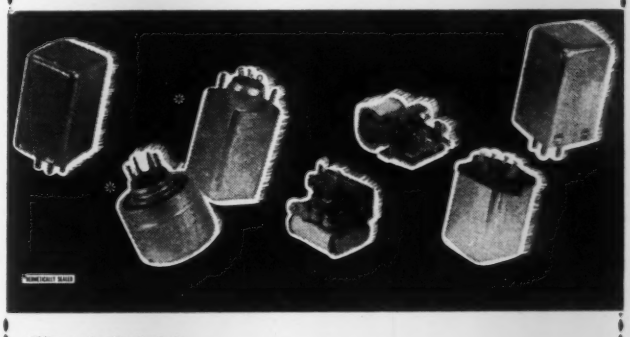

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SENSITIVE RELAYS

Sigma Instruments, INC.
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Instruments in the War Effort

"Special Issue" on Product Testing

Numerous Tests Assure Safety of Lifting Jacks

PRIDE is taken by Templeton, Kenly & Company, Chicago, the world's largest manufacturer of industrial lifting jacks, in carefully load testing every jack through its full travel. The jacks range in capacity up to 1000 tons. Production includes lever or rack type jacks, screw jacks and hydraulic jacks.

Modern and approved equipment is installed in the company's testing department to make sure that every jack shipped comes up to specifications. Some of these testing machines are pictured:

Fig. 1 shows in use a Brinell hardness testing machine. This tester is so widely known that the term "Brinell" has become synonymous with hardness when applied to metals or parts. All rack bars, sockets, pawls and other load-carrying parts of Simplex jacks are subjected to the Brinell hardness test.

Fig. 2 shows a Tinius Olsen tensile and compression testing machine. This rugged machine shows the resistance of jack members and assemblies to compression, as well as tensile stresses.

Fig. 3 shows a specially-designed hydraulic testing machine which was built so as to test each jack for its full travel at its rated capacity. Simplex jacks are spot tested for overload capacity during production testing.

Fig. 1

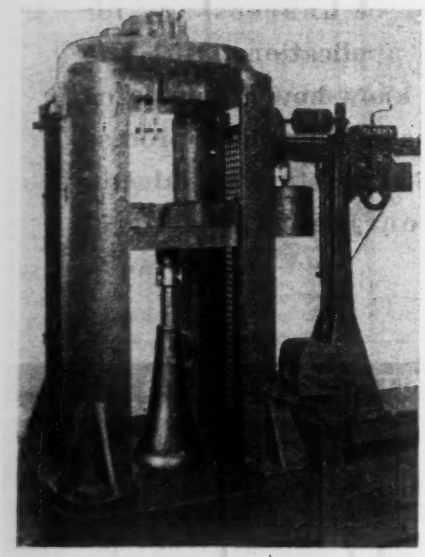

Fig. 2

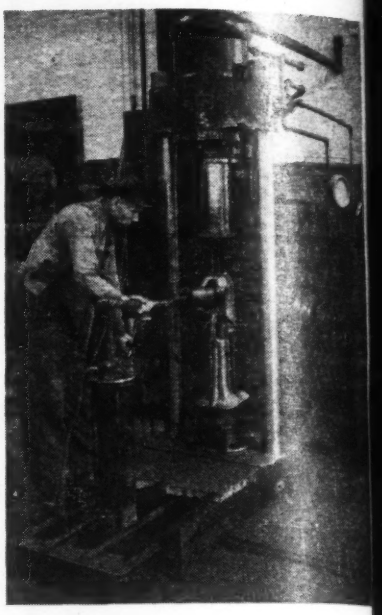

Fig. 3

In designing a new jack or new model a sample is made which undergoes the most abusive field tests to determine its worthiness, before the jack is finally approved for production.

Since Templeton, Kenly & Company was founded in 1899, safety has always been the first consideration in the design of its jacks. They have received several awards from engineering organizations for the safety features incorporated in their jacks. Building safe jacks obviously calls for ample use of testing and inspection instruments.

Durability Tests for Electrical Products

SCHENECTADY, N. Y.—By deliberately destroying newly designed products through gruelling tests which twist, stretch, tear, shatter, smash, crush, corrode, burn and freeze the General Electric Company determines the extent of durability of materials and finished products, and detects any defects in design or construction.

Temperatures are made more extreme, speeds increased, and loads made many times heavier than in actual operation. The tests are not complete until an article has torn itself apart. Some tests last months or years, while some are speeded up to crowd a month's torture into an hour.

As an example, G-E engineers have kept a turbine bucket vibrating for fifteen years. During that time the bucket has vibrated more than 100 billion times, and only when it falls to pieces will the test be considered complete.

Some materials, usually unfinished products, are tested for "twistability" on a rotating fatigue machine with an eccentric drive, which rotates and bends the sample material until it breaks (Fig. 1). Some samples have been strained 10,000,000 times before they were destroyed.

G-E turbosuperchargers, which play a major role in the superiority of America's bombers and fighters, are

Fig. 1. Motor shaft being tested for fatigue with load applied at end of shaft extension.

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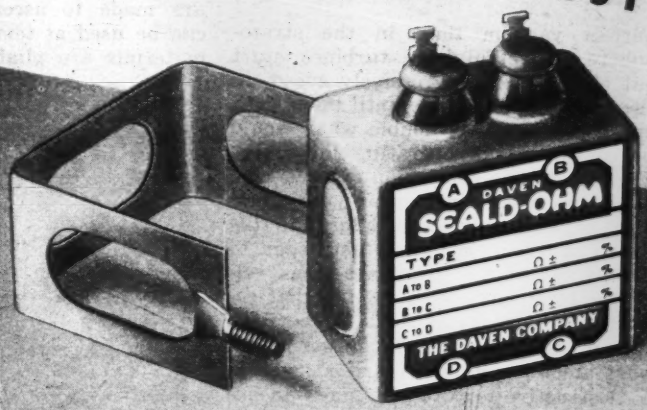
DAVEN

WIRE-WOUND SEALD-OHM

HERMETICALLY-SEALED PRECISION RESISTOR



Totally unaffected by extremes of humidity and temperature, highly resistant to vibration and shock, with provision for rigid mounting . . . these were "specs" that could not be met by any resistor on the market. In response to a direct request, DAVEN, applying the know-how of over two decades of precision resistor engineering, carefully designed and built a new, completely hermetically-sealed resistor. DAVEN SEALD-OHMS squarely meet these specifications. This was proven by exhaustive tests conducted by a famous research laboratory.

SEALD-OHMS are ruggedly constructed throughout, with special attention given to combining vibration and shock resistance. Their physical design enables the combining of several circuits within a single unit. A unique mounting bracket arrangement adds to the broad adaptability of these resistors. SEALD-OHMS are intended for use in any equipment subjected to humidity and temperature extremes. They fully meet both Army and Navy Specifications. Typical applications include as secondary standards, resistor elements in bridge networks, in voltage divider circuits, in attenuation boxes, etc.

ELECTRICAL DATA

RESISTOR WINDINGS: Either spool or mica-card type, depending upon engineering requirements. Non-inductively wound and carefully aged to remove strain before final calibration.

RESISTANCE RANGE: Any desired value may be had; maximum 1,600,000 ohms depending upon type of resistance wire employed.

TEMPERATURE CHARACTERISTICS: Four types of resistance wire of different characteristics are available.

ACCURACY: May be had to tolerance as close as ±0.1%.

FREQUENCY CHARACTERISTICS: No appreciable effect over the audio range. This range may be exceeded to meet many other applications.

CIRCUIT COMBINATIONS: Resistors available with 2 terminals at one end or 2 terminals at two ends. A single four terminal unit is designed to take up to four separate spool-type resistors of different values and accuracies.

MECHANICAL DATA

SHIELDING: Drawn brass, completely hermetically-sealed. Thermal-shock tested for faulty seals before shipment. Treated to withstand 200 hours salt spray test (f-13 AWS Spec C75.16-1944).

TERMINALS: Electrical connections are brought out through fused glass seals which are soldered in the resistor shield.

MOUNTING: A specially designed steel bracket with spade lugs welded to the sides is supplied with each unit. Cut-outs on this bracket engage with embossings on the side of the brass shielding to enable firm mounting of the unit in a vertical, inverted or horizontal position.

DIMENSIONS: 1-9/16" wide, 1½" high, ⅞" deep. Add terminal height, 9/16". Studs on mounting bracket, 1-11/16" between centers.

For additional information, write to THE DAVEN CO., 191 Central Avenue, Newark 4, New Jersey

DAVEN *pioneer maker of precision resistors*

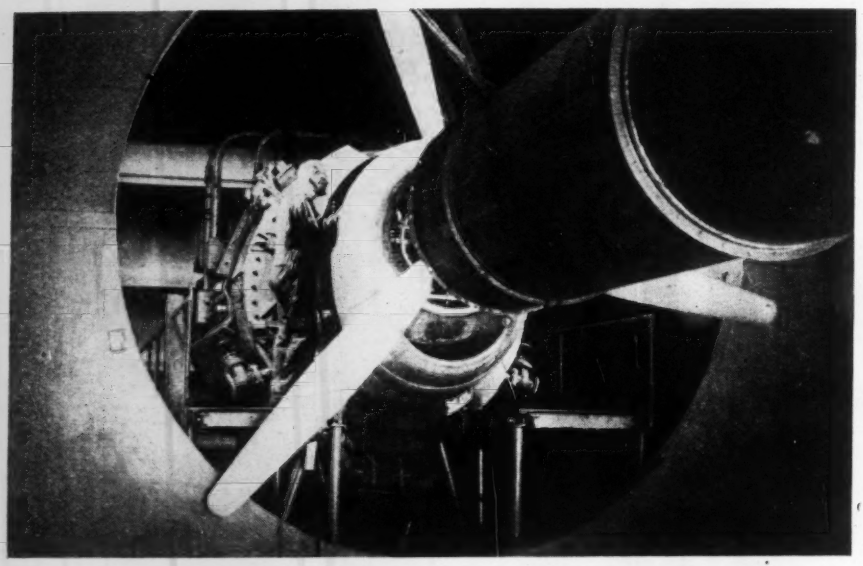


Fig. 2. Turbosupercharger in the scientifically built test chamber where it is being tested for high-altitude flying conditions of temperature and pressure.

Fig. 3. Shown in a superspeed photo at the very moment it cracks and begins to fly apart, the supercharger wheel is spinning faster than 40,000 r.p.m. and the outer edge is traveling over 2000 feet per second.

tested on the ground under conditions they would normally encounter while being flown at 50,000 feet.* These tests duplicate the punishment of the substratosphere in scientifically built altitude test chambers (see Fig. 2). Hot gases reaching temperatures up to 2000°F. can be introduced into the turbines at rates as great as 450 pounds per minute, or, in another test chamber, 1200 pounds per minute of refrigerated air at −100°F. can be supplied to the compressor.

Tests on individual parts of the turbosupercharger are so violent they duplicate in a few minutes the same effects encountered by the unit during its life on the plane. Supercharger wheels meet their death on special high-speed vacuum stands. First the test chamber is evacuated to a more nearly perfect vacuum than in the stratosphere. Powerful-drive turbines start out slowly and progressively speed up the whirl of the wheels until they reach speeds as much as double what would be considered an operating limit (see Fig. 3). At the conclusion of each run, engineers carefully measure the diameter of each wheel to determine the speed at which the metal first began to stretch out of its normal shape, as well as the total amount of stretch that occurred before it cracked. To perform all of these turbosupercharger tests, vast amounts of power are consumed.

Destructive torture also plays an important role in the development of long-wearing electric motors. Those required in ordinary service to operate where the very atmosphere may destroy the insulation, such as in a wet cellar or in connection with chemical processing, are given the salt-spray test (see Fig. 4). Others designed for functions in aircraft are subjected to special tests in low-temperature ra[illegible]-atmospher[illegible] chambers simulating the effect of high altitude flying. On the other extreme motors are also tested for their behavior under tropical conditions imposing high temperature, extreme moisture, and fungus hazard.

One of the most severe of all tests which the G-E motors were called upon to face occurred in the development of explosion-proof motors. Such motors as used in refineries, for example, have been explosion-tested by installing them in a specially constructed box, after which atmosphere both inside and outside the motor is filled with specified mixtures of high-test gasoline-vapor and air. With the motor running, the vapor inside the motor is exploded. Only if the atmosphere outside the motor is not ignited, and if the motor housing is not cracked or broken, does the motor pass the test.

The amount of stretch in metal is determined by creep tests. These tests are made to ascertain what stresses can be used at temperatures where all materials are pliable, without causing

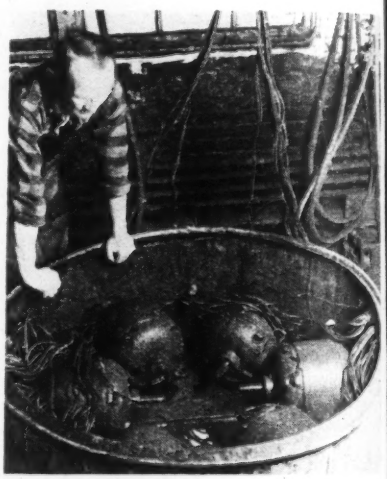


Fig. 4. Induction motors being inspected after insulation life test in salt-spray tank.

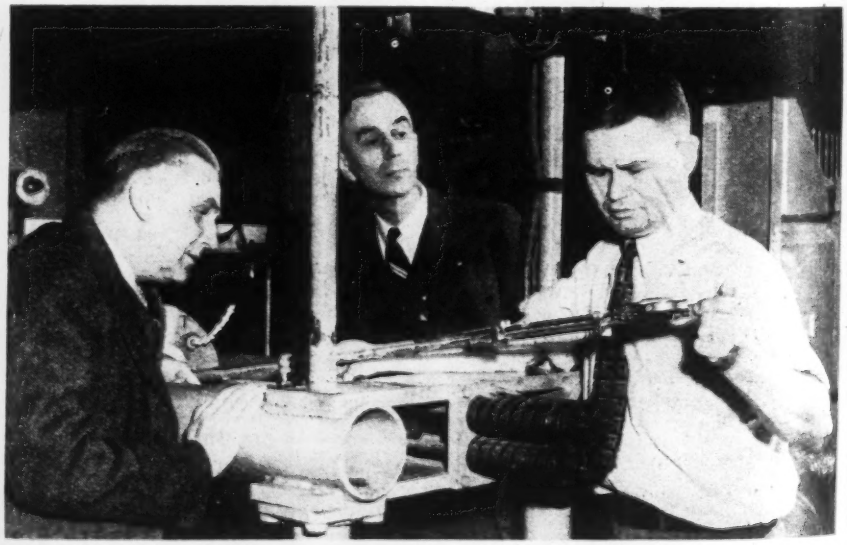


Fig. 5. W. E. Ruder, of the research laboratory, and E. L. Robinson, of the turbine engineering department, watching Frank Lorenz as he withdraws the first of the four 100,000-hour test rods from the furnace.

*For a technical article see "Turbosupercharger Testing" by E. E. Stoeckly, *Instruments*, Jan. 1944, pages 19-23.

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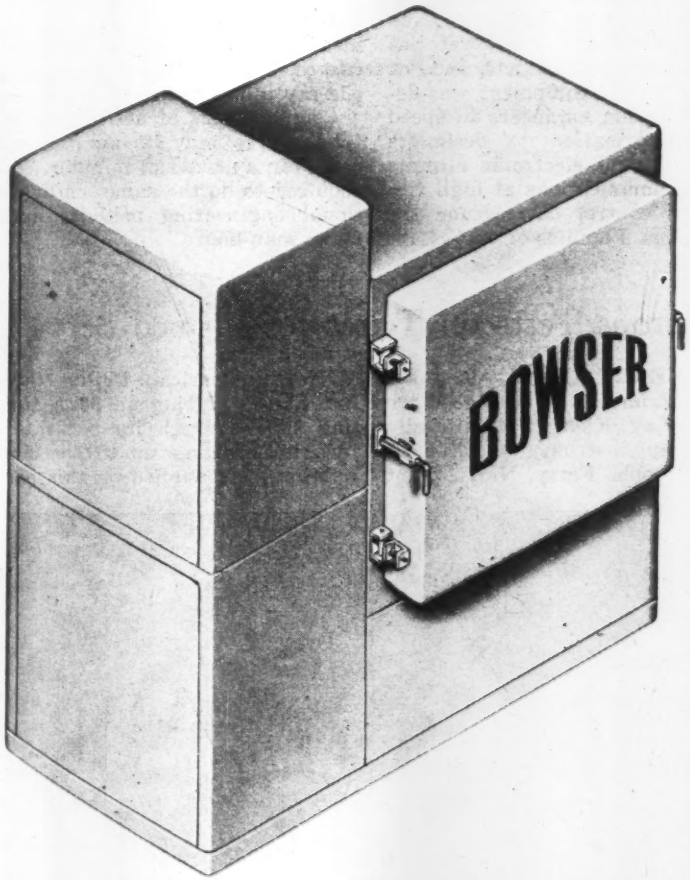

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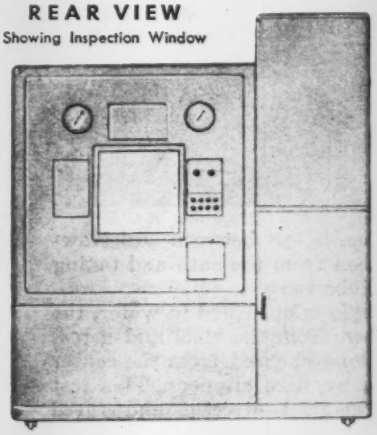

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deformations larger than the values tolerable in high-speed machines. A metal rod is placed in an electrically heated furnace run at a temperature of 842°F., with a constant stress of 13,000 lbs./in.^{2} on a 12" portion of rod. Tests have been run for 100,000 hours (approx. 12 years) for improving steam turbines so they can operate at higher temperatures.

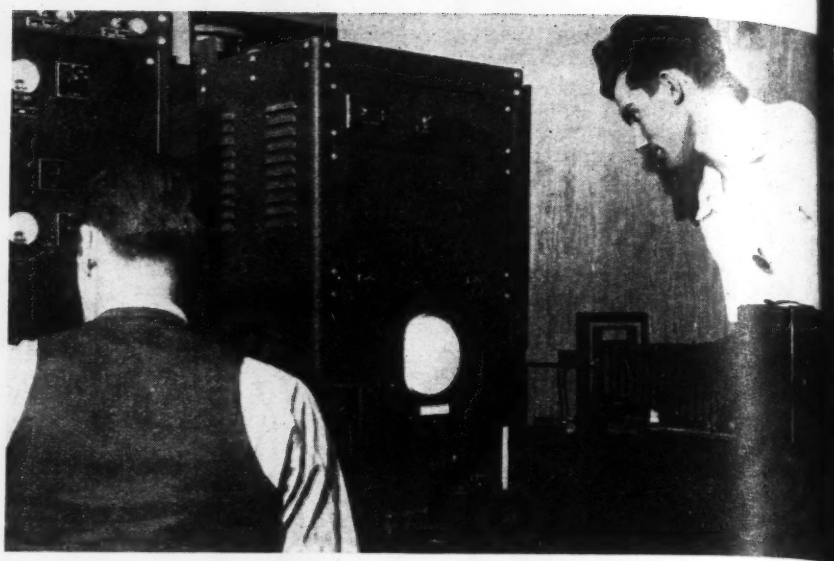
Novel Test Sample Speeds Tap Carbon Analysis

PITTSBURGH—Tap carbon analysis has been speeded up considerably at National Tube Company's National Works, McKeesport, Pa., by a novel sampling procedure now in standard use at several United States Steel Corporation subsidiary plants. The procedure consists of taking a test spoonful of slag-free metal from the open-hearth furnace bath, killing the steel with aluminum wire and drawing a column of approximately 6" of clean steel up into a 6-mm. Pyrex glass tube by means of an ordinary 1-oz. rubber bulb. Caution must be exercised to assure that no slag covers the surface from which the sample is drawn and

that no time is lost between withdrawing the spoon from the bath and taking the glass tube sample.

The sample is quenched in water, the glass broken from the steel and a test piece ¾" long sheared from the center of the rod by wire clippers. This test piece is weighed directly and fused under standard conditions in a high-temperature combustion furnace for carbon determination. The entire process requires approximately 12 minutes.

The test piece is ideal for carbon analysis since it is free from scale, segregation and pipe. Experience with the new test shows a substantial saving in furnace time after a heat has been "blocked" and an improvement in the control of ladle carbon analysis. Patent applications have been filed covering the new test and procedure.



Cathode-ray Tube Plots Electron-tube Characteristic

EMPORIUM, Penna. — Characteristic curves of individual electron tubes are being obtained quickly by means of cathode-ray tube apparatus developed in the research laboratories of Sylvania Electric Products, Inc., at Emporium, Pa. The equipment was designed by Sylvania engineers to speed vital tube information to designers working on critical electronic circuits for radar, communications at high frequencies and control devices for the Armed Services. Families of curves are scanned on a cathode-ray tube scre in rapid succession. The operat shown at left, simply places a tube the circuit and makes a few adju ments. A photographic record of t curves is taken directly from the ca ode-ray tube screen by the camera

Complete sets of accurate individu tube curves may be scanned and r corded in a matter of minutes. The ti required to do the same job by conve tional engineering methods would many man-hours.

Numerous Tests on Tubes for Armed Services

DOBBS FERRY, N. Y.—It takes numerous instruments to do a good job of testing. Kay Kieltyka is literally surrounded by instruments while at work at the Dobbs Ferry, N. Y., plant of North American Philips Compan Inc. She is putting an 832A transmi ting tube through its paces to ma sure it measures up to specificatio Routine tests applied on this panel i

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Here's a new Engineering Bulletin that gives complete information on IRC Type BT (Insulated Metallized) and BW (Insulated Wire Wound) Resistors. Its eight pages contain interesting construction facts, characteristics, JAN Type Numbers and a list of resistance values.

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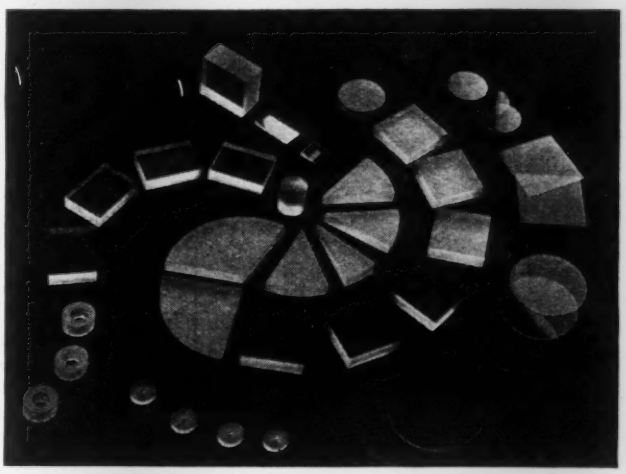

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Supplying the Armed Forces is our present job. The following improved high-quality products are available for advanced delivery dates to the instrument manufacturer, to help facilitate this war effort.

- *Babinet Compensators:* the device to be used in measuring the quantity and quality of strain in glass and for measuring types of polarized light.
- *Retardation Plates:* thin quartz plates for producing phase differences of the various wave lengths of light.
- *Polished Crystals:* special quartz crystals for supersonic applications.
- *Bertrand Plate:* a split phase quartz plate for more accurate determination of plane of the optical axis and the x-axis than can be accomplished with a single polariscope.

Look ahead . . . but look to VALPEY for crystals and specialties in quartz fabrication.

See us first when problems arise in the use of quartz. Our facilities, geared to war, will be equally well geared for peace. Our business is to apply the correct solution to your problem . . . just send us specifications and requirements.

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With a HYPOT you can quickly locate insulation faults that would burn out in service.

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has ample capacity for all testing. Quick, easy control from 0 to maximum voltage. 5 models available for all services.

EASILY PORTABLE UNIT

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233 South Green St. Chicago 7, Ill.

clude current and voltage measurements on the plate, screen and filament. Tubes are also checked for presence of gas. Some idea of the diversified measurements can be obtained by reading the labels on a few of the twenty-two instruments: "heater cathode voltage," "heater cathode current," "plate volts," "screen volts," "filament volts," "plate current," "screen current," "filament current."

World War II has been materially shortened because of the part played by electronic tubes. Without good instruments, our phenomenal tube production would have been impossible.

Air-conditioned Manufacture and Testing of Instruments for Armed Forces

SYRACUSE, N. Y.—One hundred sixty-four thousand pounds of ice is a whale of a lot of ice. But one large and two small Carrier refrigerating machines supply the equivalent to the melting of that much ice each day at the plant of Rauland Corporation, Chicago, to help manufacture, test and age instruments and for both frigid and tropical climates.

In a 50-foot square room at the plant of the Rauland Corp., cathode-ray tubes used in communications equipment are manufactured to meet rigid tests for extremes in climate. Air in the room itself is held at 68°F. and 50% relative humidity, to assure accurate processing and proper aging.

Carrier refrigerating equipment also supplies the low temperatures used in the Rauland special "cold-and-hot" box used for testing instruments in simulated extremes of weather, to make sure that they will perform accurately and reliably in combat areas in any part of the world. The cabinet is automatically controlled so that the temperature may be raised or lowered in steps of 9° at 15-minute intervals. It can be held at 22° below zero, 122° above, or at any temperature between those two. For high temperatures, the air is warmed by electric strip heaters.

Clean air is required in the manufacturing processes. Electrical precipitation, the cleaning element in the air-conditioning system, removes air-borne dust. The conditioned air is supplied by two central-type systems, each circulating 15,000 cubic feet of air a minute to the manufacturing area.

In addition to supplying low temperatures for the test cabinets, Carrier air conditioning and refrigerating equipment helps to produce sensitive instruments at the Rauland Corporation plant. A self-contained air conditioning unit maintains a temperature of 80° to 82°F. in a coating room even during the hottest weather. The dark room, used for inspecting silver-plated surfaces, is likewise air-conditioned.

The quartz crystal calibration room at Rauland is conditioned to 68°F. and 40% relative humidity. A crystal ¾″×½″×1/16″ thick serves as a master setting for frequency-meter calibration. The crystals are ground to a perfect flat and thickness to vibrate at exactly 1,000,000 cycles per second. The room for the precision work is supplied with 2,000 cubic feet of conditioned air per minute by a Carrier unit.

Large quantities of heat are liberated from torches used by glass blowers in making cathode-ray tubes. The room in which this operation occurs, about 20 feet square, would become unbearably hot if the heat were allowed to accumulate. So forced ventilation is provided. Air circulation and cleaning for the glass blowing department are also provided by Carrier equipment.

The diversified uses of controlled temperature, humidity, circulation of air and air cleaning in the Rauland plant are typical of applications of air conditioning as a manufacturing tool.

Electron Microscope at Cancer Research Center

WASHINGTON—A one-ton electron microscope powerful enough to magnify the wind-pipes of mosquitoes to a size of approximately 2″ has been added to the arsenal of scientific instruments for the study of cancer at the National Cancer Institute, Bethesda, Md., Surgeon General Thomas Parran, of the Public Health Service, announced.

Although installed in the National Cancer Institute, the microscope will not be restricted to the study of cancer but will be available to other divisions of the National Institute of Health, Dr. Parran pointed out.

Costing $13,000, the microscope, built by the Radio Corporation of America, is the ninetieth in this country. It uses electrons instead of light rays, and magnetic fields instead of glass lenses, to peer into submicroscope worlds. It has revealed for the first time how disease-fighting organisms in the blood attack disease-producing viruses. The highly-magnified photographs (or electron micrographs, as they are termed) show how the body protects itself from infantile paralysis, smallpox, influenza, the common cold, yellow fever and other diseases. These micrographs are important factors in determining the effectiveness of various methods of treatment. The microscope will also enable scientists to compare diseased tissues with healthy tissues under direct magnifications of 10,000 to 75,000 diameters.

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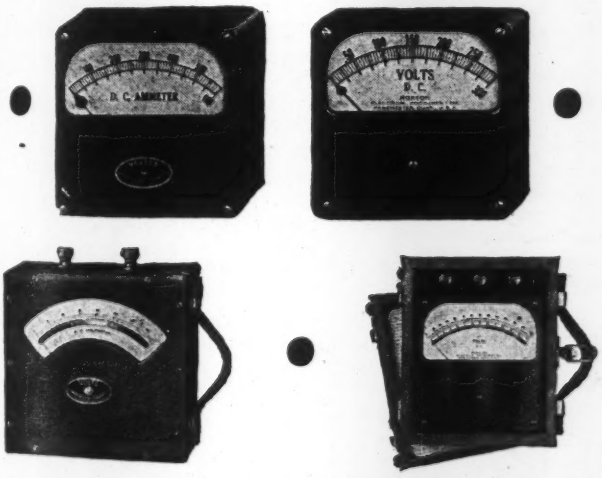
Electrical Instruments



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Bench assembly and repair means speed-up in production. The use of Cannon Multi-circuit Connectors in the wiring of electrical equipment is the ultimate in assembly efficiency—time saved on the job, less skilled labor, better critical work under better conditions.

Bench wiring by Jean Wheeling of the Curtiss-Wright Corporation, Columbus, Ohio

Various parts of electrical assemblies may be manufactured in different factories and put together and into operation simply by inserting a Cannon Plug into a Cannon Receptacle. The connection will be firm, tight and solid—yet quickly disconnected for replacement or repair.

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Wherever quick, complete and sure electric connections must be made—whether for a single element or a maze of circuits—use a Cannon Connector. Nothing less is so surely satisfactory. Nothing better can be had.

Write for the condensed Cannon Catalog. It gives you a general introduction to the Cannon line. Address Dept. A-141, Cannon Electric Development Company, 3209 Humboldt St., Los Angeles 31, California... *Below is pictured a wall mounting, typical of the famous Cannon AN line of plugs.*

CANNON ELECTRIC

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Los Angeles 31, California

Canadian Factory and Engineering Office:
Cannon Electric Company, Ltd., Toronto

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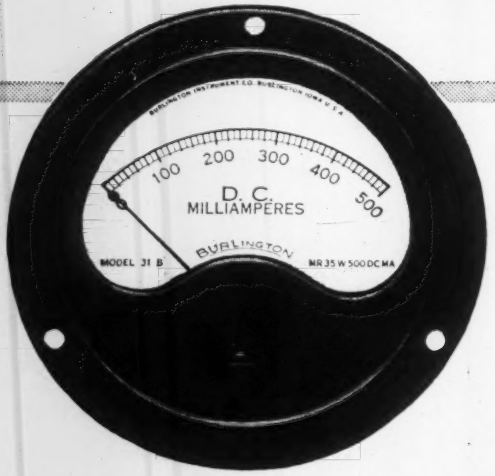
Burlington

PANEL INSTRUMENTS



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Exceptionally high torque to weight ratio of control springs to moving element insures minimum error under conditions of shock, vibration, and other rough usage.

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All ranges AC & DC are available in 2½", 3½" and 4½" sizes, both square and round, flush mounting.

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AUTOMATIC CONTROL

Continued from Page 453

fected. Even now these possibilities are being given recognition.

The preparation of this talk has been a very interesting experience to me. My attempts to classify and to group for presentation to you the errors we find recurring as we go about selling and servicing in your plants, have brought to me more forcibly than ever before the realization that we (meaning you the users and we the manufacturers of these devices) are engaged in the development and application of an art, and that we have, by coöperative effort, made surprising progress.

I began the preparation of this talk by attempting to prepare a series of drawings which would illustrate some of the points I have mentioned. I had the feeling as I progressed, however, that the greatest errors that are occurring are of a kind that could not be illustrated by drawings. They are errors of conception, of coöperation and attitude. Errors that required for their correction the development and education of personnel, a mutual conception of our problems and an appreciation of the economic and physical limitations which have and will continue to hamper the realization of the ideal conditions which would make our work easy.

The art of metering has been quite highly developed and much has been written about it, and if the same precautions are taken in the application of metering to control as are commonly given to recorded metering, many of the common errors encountered in the application of control will be avoided.

I have made no mention of the timing and speed of control operation although it is of great importance, especially in cases where there are a number of control or governing devices which are required to operate together and where each has an effect upon the operation of the other. Such cases need to be dealt with individually and the instruments used should be built with wide ranges of adjustment for stabilization and speed of operation. The speed with which a furnace or a turbine or a process will respond to regulation is usually unknown until after the control installation is put into use, and unless the control instruments are capable of being brought into synchronization with this speed of response, hunting is sure to occur.

In most cases it would be a decided economy for a purchaser of control to include in his budget and his order, provision for the services of a competent engineer to supervise the installation of the equipment and to train the operators in its use. In this way, many mistakes would be avoided and the benefit of experience with the equipment would accrue to the purchaser immediately, and usually the time and materials saved by doing the job right the first time will pay the cost of such service.

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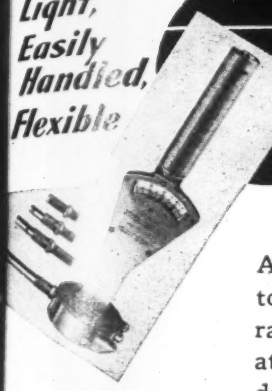

A reliable precision indicator especially designed for rapid, convenient and accurate measurement of internal diameters.

Variations of as little as 0.00005" in size, out of round, and taper of bores can be quickly determined. Hundreds are in daily use on production lines and in inspection departments on innumerable applications where close limits on size, roundness and straightness of bore are of prime importance.

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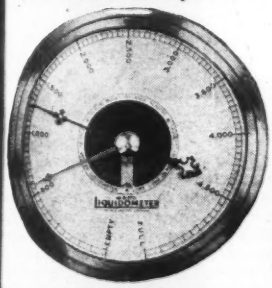

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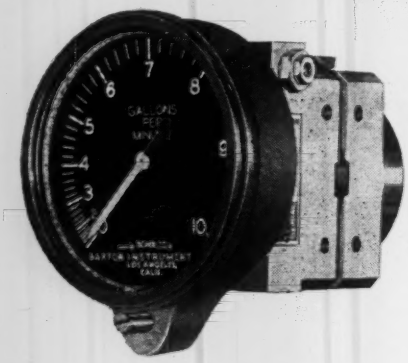

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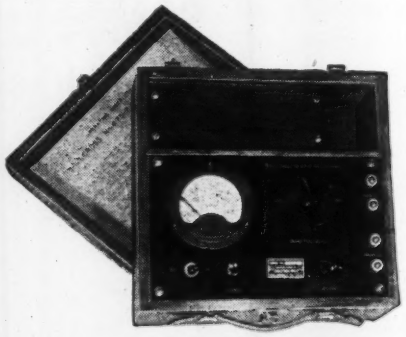
The Month's NEW INSTRUMENTS

In this department we report each month new devices for measurement, inspection, testing, metering and automatic control—in the form of concise technical descriptions. When writing to manufacturers directly, please mention this department. Or write to Information Section, Instruments Publishing Company.

Medium-range Milliohmmeter

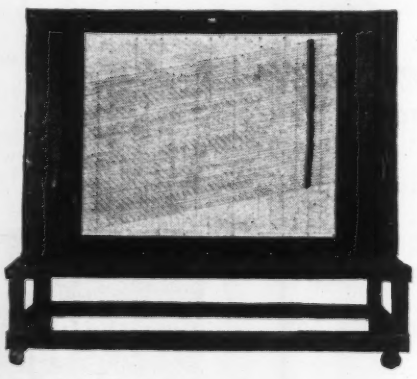
New "No. 673-F" Milliohmmeter has linear scales which eliminate crowding higher values of resistance at one end of scale. The six scales have ranges as follows:



0-0.5-1-5-10-50 and 100-ohms full-scale. This range of resistance measurements bridges the gap between maker's regular milliohmmeters used for low-resistance testing and ordinary ohmmeters used for relatively high resistance measurements. This new instrument utilizes separate connections for current and potential to minimize effect of lead and contact resistance when measuring low values. The instrument uses a single No. 6 dry cell battery carried in a battery compartment built into the instrument.—*Shallcross Mfg. Co., Collingdale, Pa.*

Multiple Manometer

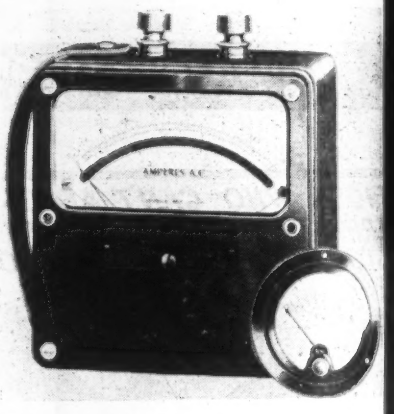
Undersigned company has been licensed by Consolidated Vultee Aircraft Corp. to build new Consolidated-designed 50-tube inclined tube manometer. Divisions on scale



are horizontal, from 1 to 10 inches, calibrated in tenths, which makes possible high accuracies. Wells are aluminum or stainless steel. Unusual tube and well arrangement is leakproof. Instrument is relatively light and compact, and is portable. This 50-tube inclined tube manometer is designed for use in wind tunnel research laboratories, and may be adapted for use in low-pressure, medium-pressure, high-speed or supersonic wind tunnels. It may be used with a wide range of indicating fluids of different specific gravities. A unique, leakproof, multiple-type tube connector is available for making rapid connections to the instrument. —*Trimount Instrument Co., 78 W. Van Buren St., Chicago 5, Illinois.*

Frequency-compensated Electrical Instruments

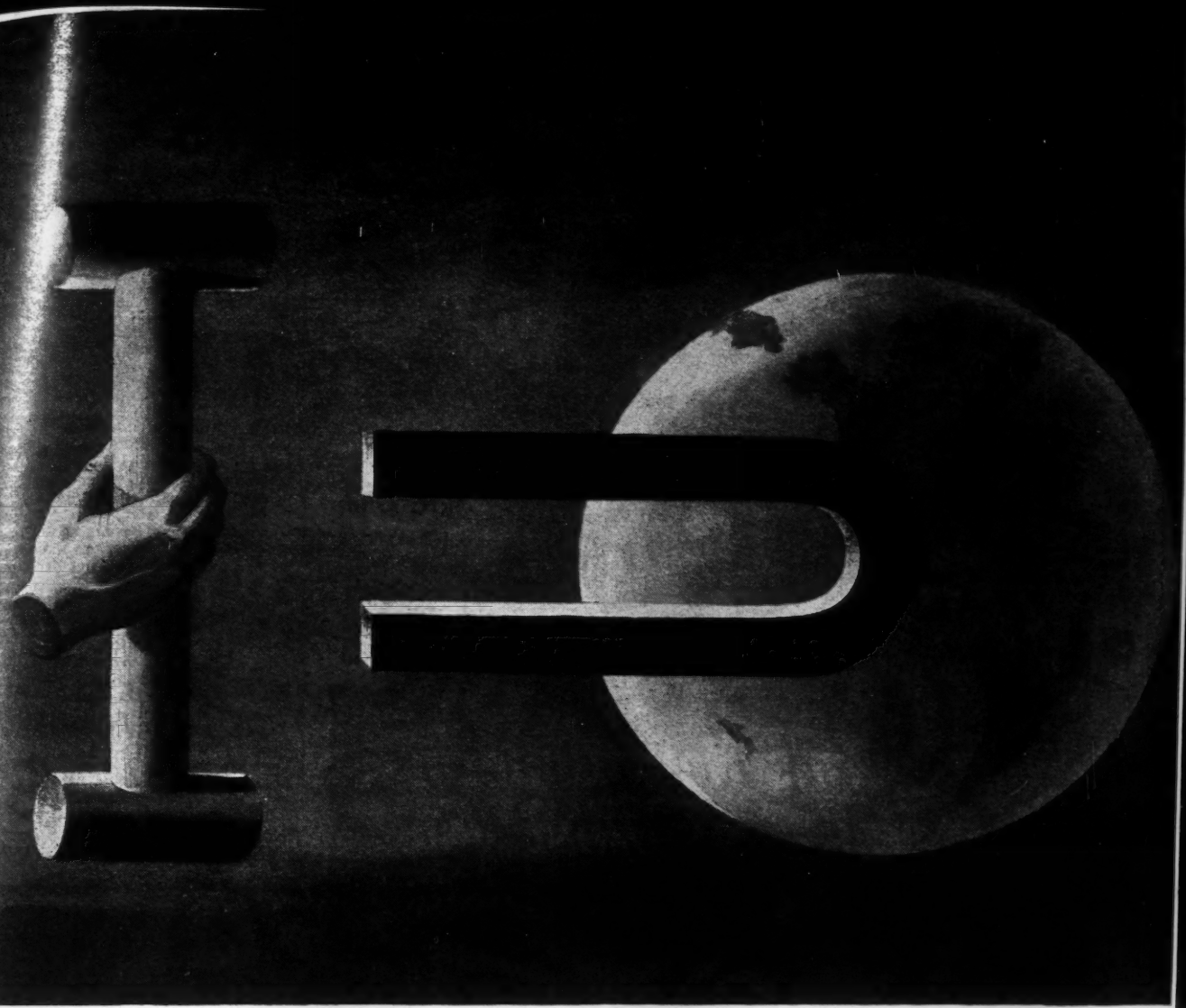
New electrical measuring instruments of the iron-vane and dynamometer types have special forms of compensation to maintain their accuracy over the broad frequency



range of 25 to 3000 cycles. At present, such a-c instruments with this special compensation are used by the Armed Forces; and it is said that these instruments will prove highly advantageous to industry in those applications using power frequencies above 60 cycles, with the smaller associated transformers, higher speed motors and simpler rectifier systems. These frequency-compensated instruments are furnished as ammeters, voltmeters and wattmeters in both the portable and switchboard types; also compensated up to 1000, 2000 and 3000 cycles.—*Weston Electrical Instrument Corp., 617 Frelinghuysen Ave., Newark 5, N. J.*

Fixed Paper-dielectric Capacitors

New hermetically-sealed fixed paper-dielectric capacitors for d-c applications, designed in accordance with proposed JAN-C-25 and used primarily in electronic equipment for the Armed Forces, are available in case style CP-70, characteristics E and F. There are 268 standard ratings in the CP-70 class, ranging from 0.1 to 15 microfarad, for circuit voltages from 600 to 12,500 volts. All ratings have a capacitance tolerance of ±10%. Physically, standard units vary in size and weight from small units weighing 3 oz. to large, high-voltage units weighing up to 50 lbs. Metallic rectangular cases are of hermetically-sealed construction, with bushings brought out



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SEARCH FOR induced or residual magnetism in aircraft or ships, magnetic fields in cargos, the location of hidden pipes, conduits, etc., is greatly facilitated by the Waugh Gradientometer.

This instrument is so designed that the earth's field is cancelled out and, in consequence, other magnetic fields are immediately indicated and easily located.

The Gradientometer needs neither leveling nor adjustment for measuring the change in strength, or gradient of magnetic fields. The snap of a switch converts it to a *magnetometer* for measuring the strength of magnetic fields.

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WAUGH
GRADIENTOMETER

Particularly designed for rapid magnetic inspection of aircraft or other structures to locate the source of local magnetic fields. Pick-up unit consists of two identical elements so positioned as to cancel out the earth's field. For this reason the instrument does not require leveling or orientation. Operates on 110 V. 60 cycle A.C.

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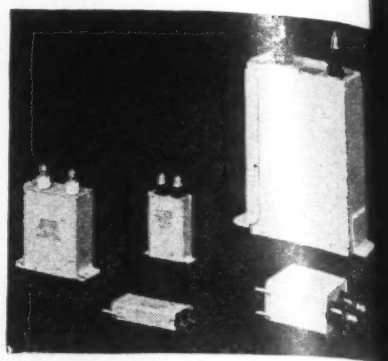
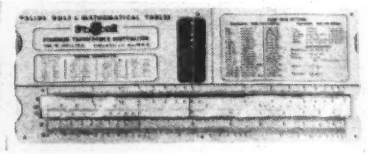


through top. Bushings with solder-lug terminals are made of molded Textolite, and the pillar-insulator E and D terminals are of highest quality, glazed, wet-process porcelain. All bushings are hermetically sealed to top of case, and are generously designed to provide adequate air strike and creepage distance. All capacitors can be provided with removable mounting brackets of either footed-type or screw-spade-lug type for mounting in either an upright or inverted position.—*General Electric Co., Schenectady 5, N. Y.*

Slide-rule with Eight Additional Tables

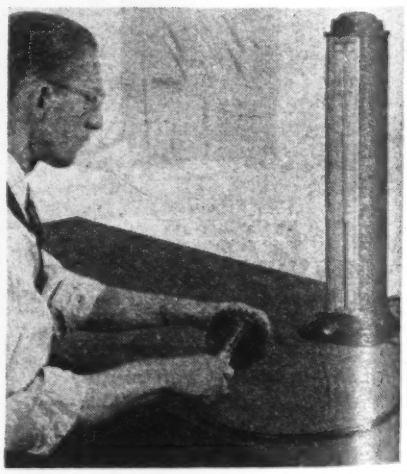
New "Multi-Slide Rule" is said to represent a compendium of tables all in one rule. It has all the values of the regular slide rule plus eight mathematical tables, "thus



practically dispensing with all need for book reference." It is made of durable stock, clear-print and has a transparent plastic indicator. — *Standard Transformer Corp., 1500 N. Halsted St., Chicago 22, Illinois.*

Air Gaging System

Undersigned company announces that it is exclusive sales agent for air gaging system manufactured by Metrical Laboratories, Inc., Ann Arbor, Mich. Henceforth to be known as "Federal Metricator System of Dimensional Gaging by Air," it is a further development of the system first described in *Instruments*, July 1944, page 453; also *Instruments*, Oct. 1944, page 632. Standard gaging head has two measuring orifices,



both recessed with respect to outer skirt of gaging member. This recessed design permits a part whose surface is easily marred to be precisely gaged without surface of part actually touching gaging member. It assures long accuracy-life because protective outer skirt of gaging member can wear considerably before the two measuring orifices themselves show signs of wear. "Federal Metricator Air Gaging System" operates under air pressure of approx. 1 lb.; can be attached to regular plant air supply. If attached to a high-pressure line, regulator at instrument will bring pressure down to proper level. Variations in air line pressure do not affect accuracy, as pressure in gaging system proper can be kept constant by maintaining water in instrument at correct static level. Amplification being four thousand, measurements within 25 millionths of an inch are easily readable on scale. Practically any inside dimension down to ⅛" diam. and any outside dimension down to ¼" diam. and other dimensions of depth, width, etc., can be gaged singly or together. Diametral pitch, taper, bell mouth, barrel shape, and out-of-round can be precisely gaged in one operation. Stepped holes, or holes having several diameters can be measured simultaneously by using a composite gaging member. Moisture or sludge in air line does not affect reading accuracy. Full tolerance is maintained throughout entire life of the gaging system. Design of system is such that replacements of parts due to wear is minimized. Effective range of Metricator is approximately 0.002". — *Federal Products Corp., 1144 Eddy St., Providence 1, R. I.*

Portable-tube X-ray Unit

New portable-tube x-ray equipment makes it possible to examine internal structure of welds, rivets and other vital points of stress in confined spaces such as airplane wings,

fuel tanks, etc. Shockproof tube (approximately 3" in diameter) is coupled to generator by means of a shockproof cable and two small water hoses. Water cooling makes possible compact design so useful for analysis on completed structures. In use, the X-ray tube is clamped to (or held against) the section under examination. Standard X-ray film is then placed on opposite side of area, and exposure is made. High-loading-anode tubes are available with targets of copper cobalt, iron, or molybdenum. Ratings range from 10 to 20 ma. at potentials up to 50 kvp, depending on target material. Main generator may be mounted on a dolly for movement to certain stations where electrical and water connections are available. It may also be assigned to a fixed location where parts are brought within reach of the tube. Controls include a stepless kilovoltage regulator, filament rheostat,

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Now, you can get HICKOK precision and dependability in a new line of hermetically sealed meters. Available in 2½", 3½" and 4¼" round styles. Dimensions of American War Standards Assn. Drawings C39.2-1 and C39.2-2. The 4¼" size is built especially for use in radio service equipment where several scale arcs are required.

All instruments are hermetically sealed and both vacuum and pressure tested under water. Case fabricated of pressed steel and made corrosion resistant to meet specifications. Terminals are a special glass soldered-in type.

All meters are fully shielded, permitting use on either magnetic or non-magnetic panels. Operation is accurate and dependable even up to 85° centigrade. Internal pivot construction in D.C. types assures longer life and greater resistance to shock and vibration. Write for further information today.

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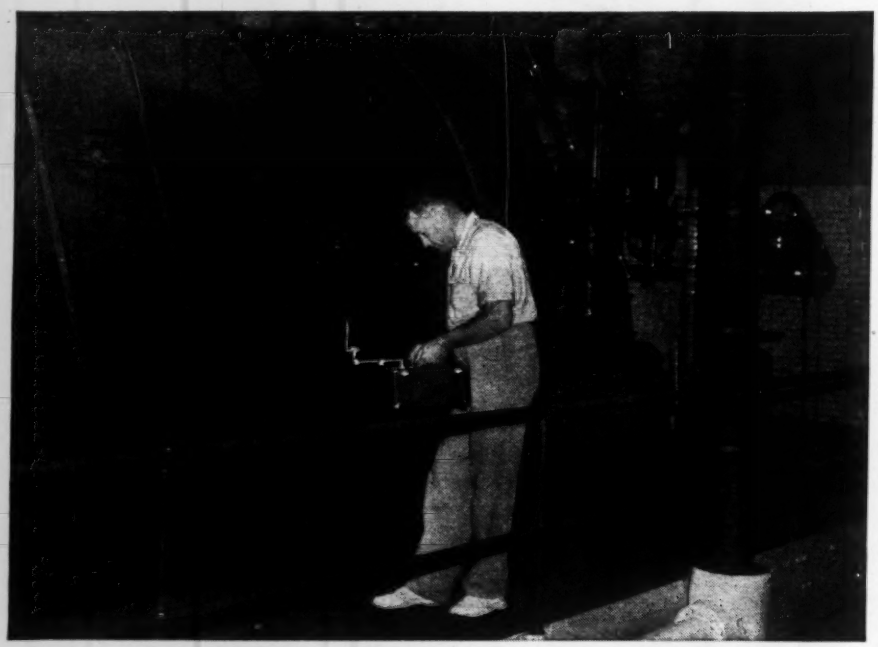
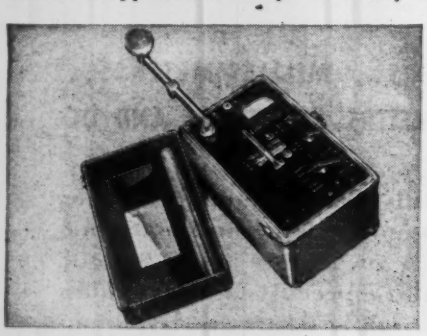
PRECISION CALIBRATED . . . LASTING ACCURACY

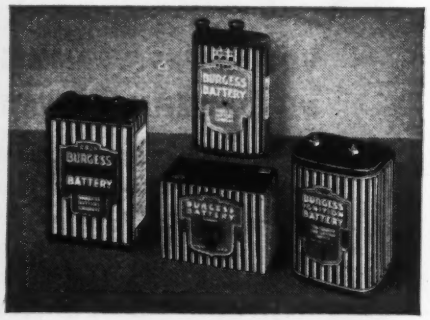
PORTABLE POWER PROBLEMS

THIS MONTH—THE SOUND-LEVEL METER



BURGESS INDUSTRIAL BATTERIES meet every power requirement for the conveniently portable sound-level meter. Used for qualitative measurement of sound, the meter consists essentially of a sound pickup, a special electronic amplifier and an indicating instrument. Burgess Industrial Batteries give dependable, long service life in hundreds of electronic industrial applications—they meet every requirement for test and control instruments.





ENGINEERS CHOOSE BURGESS Industrial Batteries for the operation of portable instruments—recent surveys of dry battery preferences reveal that Burgess is the first choice of electronic experts! Burgess engineers will develop batteries for any special problem you may have, although most needs can be readily served from the standard line available through your Burgess distributor. *Burgess Battery Company, Freeport, Illinois.*

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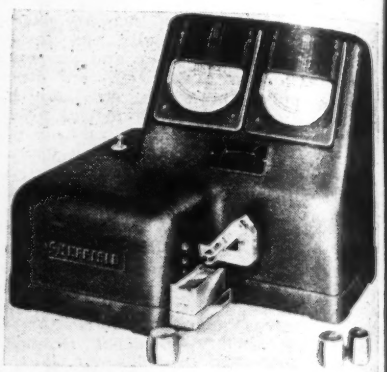
Recognized as the MOST COMPLETE LINE of dry batteries

circuit breaker (serving as main control), and a high-voltage pushbutton switch. A milliammeter is provided for proper adjustment of tube current and running-time meter records tube life. Pilot light shows when tube is energized. There is an outlet to permit use of an exposure timer. Doors of the black, crackle-finished cabinet have safety switches on the high voltage circuit. —*North American Philips Co., Inc., 100 East 42nd St., New York 17, N. Y.*

Bearing Contour Comparator

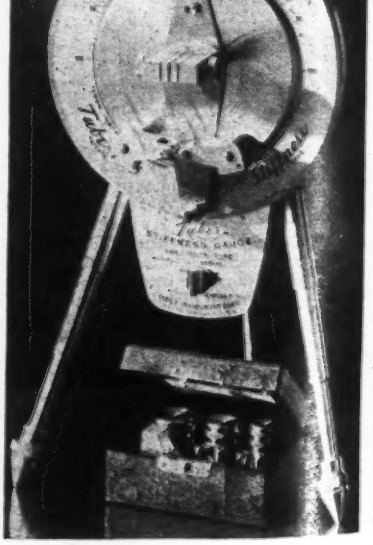
New bearing contour comparator with "Electrigage" heads checks barrel-shaped bearing rollers for correctness of contour only (no direct check is made on any



diameter. Bearing slides into gaging position on two rails, coming to rest against the fixed center arm and lower roller backstop. Upper roller is spring-loaded to exert enough pressure on bearing to keep it in gaging position while being rotated for the complete contour check. Upper and lower arms at left do the gaging while middle arm is fixed for positioning bearing roller. Gaging fingers move reed mechanisms which in turn actuate the "Electrigage" heads. Middle arm is adjustable for various contours. All three arms at left have tungsten carbide-inserts for long life.—*Sheffield Corp., Dayton 1, Ohio.*

Stiffness Gage

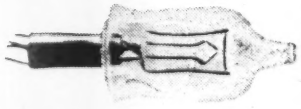
New "V-5 Power Driven Stiffness Gauge" is designed for determining standard measurements of stiffness and resilient qualities of flexible materials up to ⅛" in thickness.



as laminates, plastic, cardboard, light allic sheet and wire. Without addition ttachments, it will measure both Initial Normal Stiffness characteristics. Elas- drift or "creep" of the specimen struc- e can also be charted from the various dings. Calibrated weighing system is of dulum type, considered one of the most onsive and accurate means of measur- small increments of load. Entire pendu- n assembly (except calibration weight) made of strong aluminum alloy, minimiz- inertia and bearing friction. Face of cimen clamp is mounted exactly on cen- of rotation, insuring constant test length specimen, hence accurate and comparable t data. Set of calibrated weights furnished h instrument consists of one each cali- ated in 500, 1000, and 2000 Stiffness its. Weights of 3000 and 5000 Stiffness its are also available. For testing very n and flexible materials (below 10 units) attachment is provided that eliminates chanical friction and inertia. Instrument portable (weight 15 lbs.), can be plugged to any 115-volt 60-cycle circuit, is easy use even by those without previous tech- al experience.—*Taber Instrument Corp., Goundry Street, North Tonawanda, N. Y.*

Vacuum Thermocouples

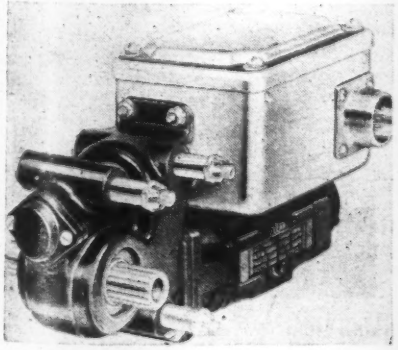
New vacuum thermocouples for high- requency measurements embody a number improvements, are claimed to possess xceptional sensitivity beginning at 1.2 mil- amperes. Extreme sturdiness and ability withstand severe impacts are said to be he result of "Thoro-Weld" process devel- ped especially for vacuum thermocouples hich must be able to withstand severe ervice. A special process is claimed to give



very stable output over extended periods of time. Where their use is indicated, rare metal alloys are used for heating elements, resulting in exceptional overload capacity. Announcement makes special mention of "Type M" high-output vacuum thermocou- ples at present available only in ranges of 100 milliamperes and over, and rated at 25 millivolts output at normal heater current. Where ordinary vacuum thermocouples would be inadequate, these "Type M" couples may be used with small, rugged instru- ments to give full-scale deflection.—*Field Electrical Instrument Co., 109 East 184th St., New York 53, N. Y.*

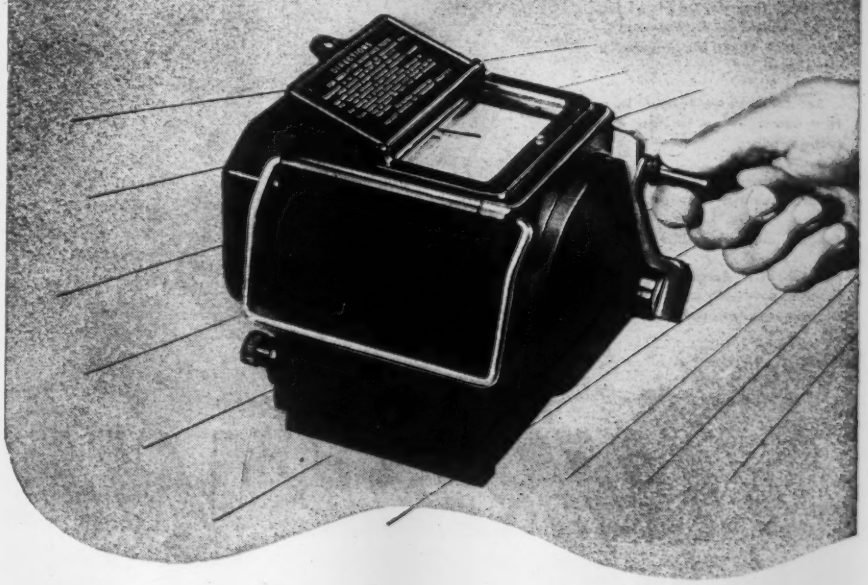
Rotary Power Unit

New "Model 111 Series Lear Rotary Actu- ator," a special low-speed unit to meet air- craft demands and for other uses, handles loads up to 600 lb.-in., operates at speeds



as low as 2.2 r.p.m. Speed and output torque are changed by using various gear ratios. Produ tion models are equipped with a double ended ⅝" o.d. S.A.E. 16-tooth spline,

WHY "Megger" Insulation Testers Have Not Been "Modernized"!



You may have wondered why we have not departed from the original operating principle of "Megger" insulation testing instruments—why we have not changed from hand operation to battery operation, or have not made use of electronic tubes or other devices. The reason is simple.

Ours is the business of building and supplying insulation testing instruments that can be depended upon to operate accurately and unfailingly—anytime and anywhere. To that end we have naturally considered, investigated and tested every element that might effect improvement. Years of research and the performance records of many thousands of "Megger" instruments have demonstrated that the classic simplicity of the "Megger" Insulation Tester with its hand-cranked generator and complete independence of any parts requiring replacement or adjustment is the best assurance of sustained, trouble-free, dependable service. "Megger" insulation testing instruments have been and will continue to be built to the high standards of fine instrument making practice.

For complete descriptions and applications of all types of "Megger" Insulation Testers write for Catalog **1685-I.**

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Reflex Torque Control by sight, sound and feel—automatically fast, involuntarily accurate.
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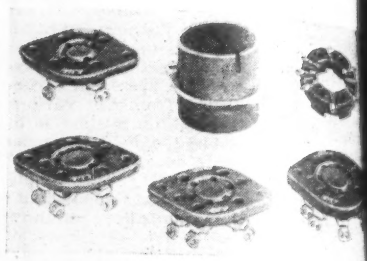
No wearing or moving parts in measuring element—no gears, levers, glass dials or fragile mechanisms.
Permanently Accurate Torque Wrenches—with automatically accurate operation.
STURTEVANT
Write for Bulletin No. S.W. 13
31 Capacities—ranges from 0-8 inch ounces to 0-7200 inch pounds.
P.A. STURTEVANT CO.
ADDISON QUALITY ILLINOIS

but special output shafts are available on request. Output shaft rotation is normally less than 360° with reversible operation. Units are powered with Lear "C" frame motors. Lear "Fastop" clutch insures accurate positioning. Thermal protectors are standard equipment on all motors in this series. Motors may be designed with as much as 30% higher torque for one direction of rotation than the other. Relation of rotation to torque with amount of torque load differential can be specified to meet specific needs. Control boxes contain suitable control gear reduction assemblies and standard limit switches equipped with adjustable limit switch cams. Unit is adaptable to bellcrank systems, sprocket chain drives, direct hinge drives for intercooler shutter controls, coolant flap controls, landing gears, wing flaps, etc. Power unit and actuator fit in a space about 8"×4"×5". Weight is slightly more than 4 lbs.—*Lear, Inc., Piqua, Ohio.*

High-frequency Tube Sockets

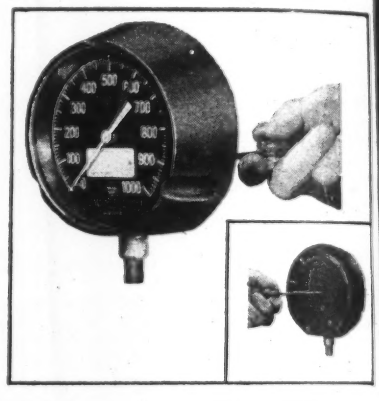
New series of transmitting and receiving tube sockets, molded of "Mykroy" mica ceramic high-frequency insulation, includes standard 4-, 5-, 6- and 7-prong, Octal and Loctal sockets for multi-prong tubes, also 5- and 7-prong Acorn sockets, 4-prong high-voltage rectifiers sockets and improved heavy-duty "50-watters." New sockets are produced by compression molding and are of one-piece construction featuring spring phosphor bronze contacts rigidly anchored. Top surfaces are perfectly flat and smooth to permit unimpeded mounting beneath chassis. Patented spring action clips provide firm, unvarying, highly conductive contact with tube terminals. "Mykroy" is said to be a greatly improved glass-bonded mica ceramic insulation which will not carbonize or otherwise deteriorate in the presence of high heat or electric arcs and flashovers, so that no leakage paths will form between



terminals where high voltages are involved. High physical stability assures permanence of form and non-warping properties. "Mykroy" is impervious to oil, gas and water, has high dielectric strength combined with low power factor and its leakage resistance is unusually high. Unlike many other ceramics it can be drilled, tapped and machined by conventional methods where modification is essential to chassis requirements.—*Electronic Mechanics, Inc., 72-90 Clifton Blvd., Clifton, N. J.*

Pointer Adjusters for Gages

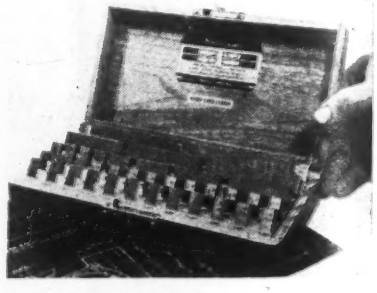
New "Hairline Pointer Adjusters" are being supplied from now on as standard equipment on undersigned company's pressure gages. With this new device, pointers



can be quickly and easily reset without removing the glass or ring—a convenience when testing gages on test pumps and dead weight testers. Slotted adjusting screw in back of case changes the relative position of the roller and the cam of the "Helicoid" movement, thus changing the position of the pointer. Fine adjustment is obtained by slight turn of the screw.—*Certified Gauge & Instrument Corp. of Long Island City 1, N. Y.*

Metric Gage Blocks

New series of Metric Gage Blocks is designed to fill the needs of domestic and foreign manufacturers working in the Metric system. These blocks are offered in two



grades that correspond in accuracy with the English system. "Inspection quality" guaranteed accurate within ±0.0001 mm. and "working quality" guaranteed accurate within ±0.0002mm. Common practice of converting English measurement to Metric can be eliminated entirely with the wide

range of measuring combinations possible. Calibrated in the Metric system, new blocks can also be used to make up English system combinations. Set consists of 38 blocks plus 2 wear blocks (of tungsten carbide in "inspection" grade) and is capable of producing over 200,000 combinations ranging from 1.01mm. to 100mm. in increments of .01mm. A special 1.005mm. block in set makes possible special combinations for closer tolerances where needed. Manufactured from high carbon chrome steel, blocks are guaranteed to exceed 65 Rockwell C hardness. A special aging process using alternate heating and freezing to 120° below zero gives blocks unusual stability, while exceptional wearing quality is possible because of the extremely fine surface finish, less than 0.4 microinch r.m.s. in the "Inspection" grade.—*Continental Machines, Inc., 301 Washington Avenue South, Minneapolis 4, Minn.*

Recording Densitometer

New electrically-operated recording densitometer automatically computes a true logarithmic graph of its findings, completing in thirty seconds a permanent curve that

formerly required a number of individual hand operations and involved the risk element of human error. Particularly valuable for detecting variations in photographic or radiographic film, the principle of operation can be utilized in any field where variations in the subject can be measured. Prototype tests extending over several months are said to have established that the unit affords greatly increased production possibilities, since it eliminates the prodigious effort formerly required in plotting sensitometric strips. Automatic plotting not only saves a great deal of labor but also makes possible a much more graphical representation of the data. Instrument was designed and built by Electrical Research Div. of Western Electric Co. and Leeds & Northrup Co. to meet specification requirements developed by *Triplett and Barton, Inc., Burbank, Calif.*

Permanent-magnet Driver Units

New "Models PAH and SAH" permanent-magnet driver units, incorporating a number of improvements, are announced. "Model PAH" has rating of 25 watts, impedance 15 ohms, frequency 100 to 6000 cycles, diameter 5¼", height 5", weight 9

WAR RESTRICTED DEVELOPMENTS

Now Available

in Televiso Series 200A Vacuum Tube Voltmeter

TELEVISO, pioneering in the production of measuring apparatus for the *SONIC to UHF SPECTRUM*, has specialized in building dependable Vacuum Tube Voltmeters.

A necessity wherever dependable voltage measurements within the range of 7 cps to 500 megacycles are required—the Televiso Series 200A VT Voltmeter is highly accurate and stable.

FEATURES:

SUPERSENSITIVE RANGE—the lowest readable voltage is .05 volts on a maximum scale range of .5 volt.

FIVE VOLTAGE RANGES—.5, 2, 15, 50, 150—spread full scale on a 4½" meter dial for easy reading. Accuracy of readings are 2% full scale; middle scale accuracy is 5% or better.

PROBE CONSTRUCTION—detachable probe to eliminate cable wear; easily dismantled for tube replacement or for soldering to tube terminals for measurements in the 250-500 MC region; flat ½" wide brass terminals connect to input to make easy soldering to test or work piece; for low frequency work up to 100 MC, removable banana plugs are spaced ¾" center to center for use with standard jacks.

MECHANICAL CONSTRUCTION—of aluminum throughout; panel and cabinet are ¼" thick (cabinet is dural.); subchassis is ⅛" and spaced off the panel by studs to simplify servicing; all components are fastened to sub-chassis.

ELECTRICAL CONSTRUCTION AND CIRCUIT—Series 200A utilizes the finest components throughout and carries a two year guarantee. The circuit is a stable plate circuit rectifier. No diode input tube is used. The plate circuit rectifier type makes available higher input impedance at all frequencies. No shorting of input probe is required for zero adjustments. All zero adjustments are made once and remain constant. A panel adjuster is available to make the unit usable without heating up time. All filament and plate voltages are transformer and tube regulated.

BUILT-IN CALIBRATION VOLTAGE—All units have a jack which produces a constant 6.3 volts for standardizing. This is the regulated filament voltage. The sensitivity can be adjusted without tools in the event tubes are replaced in the field. The Series 200A will operate satisfactorily from any source of voltage from 95 to 130 volts a.c. Line voltage surges are not observable during use.

SIZE—14"H x 9½"W x 7½"D. Guaranteed 2 years. Price $170.00 F.O.B. Chicago.

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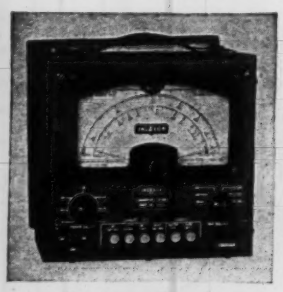
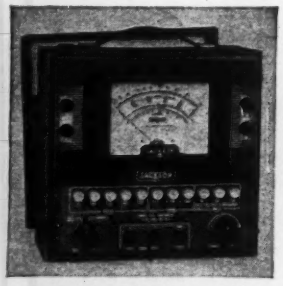
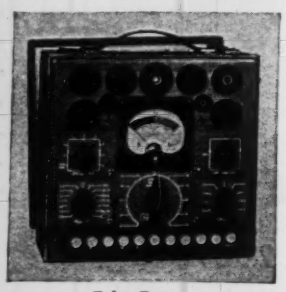


Condenser Tester
Model 650A—Measures Capacity, Power Factor and Leakage



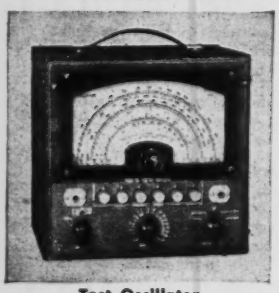
Sensitive Multimeter
Model 642—20,000 ohms per volt—complete ranges

Electronic Multimeter
Model 645—A new Jackson instrument of advanced design



Tube Tester
Model 634—Uses exclusive Jackson "Dynamic" Test Method

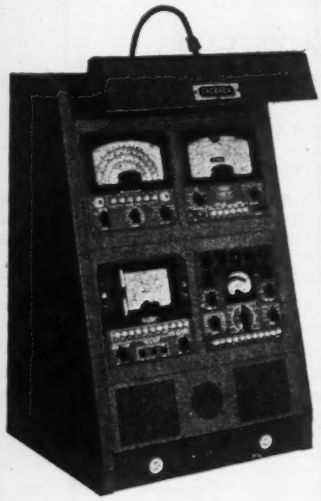
Multimeter
Model 643—1000 ohms per volt. Push key range selection



Test Oscillator
Model 640—Accurate to ½%, covers full frequency range

IT'S A PLUS VALUE of the Jackson line. Each instrument is engineered and manufactured for long accurate life, as today's users know — but every one is carefully matched in appearance, dimensions and finish as well.

Start with whichever Jackson instrument you need first. Add to it as occasion demands. Your foresight will be repaid with a matched and balanced set of instruments built to give you testing results that you just can't get with hit-or-miss assemblies. Plan now to equip your shop with these Jackson instruments. See your distributor.



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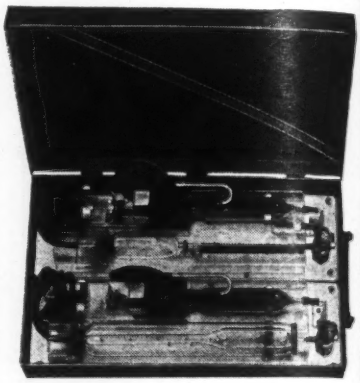
Fine Electrical Testing Instruments

JACKSON ELECTRICAL INSTRUMENT COMPANY, DAYTON, OHIO

lbs. "Model SAH" has ratin of 25 watts, impedance 15 ohms, frequency 100 to 6000 cycles, diameter 4½", height 5", weight 8 lbs. Exclusive design features include molded diaphragm flexing surfaces, heat-proof voice coil suspensions, and hermetically-sealed dust covers. Molded diaphragms are said to outlast metal diaphragms three to one. Another feature is rin centering of voice coil assembly in the magnetic gap, instead of the use of aligning pins. Maker claims that regardless of any shock or vibration, it is virtually impossible for voice coil to shift its relative position to the gap walls. Positive positioning permits a smaller magnetic gap and an increase in magnetic flux density in the gap. All units are unconditionally guaranteed for one year against breakdown.—*University Laboratories, 25 Varick Street, New York 14, N. Y.*

Gas Analyzer

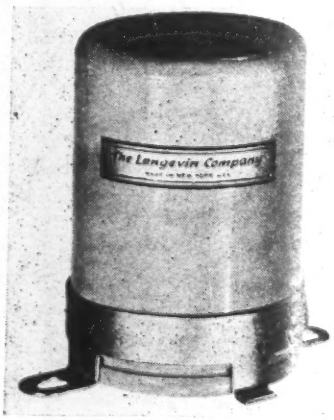
New "Series E" special analyzer has been developed for testing the high purity of oxygen, carbon dioxide, and nitrogen in range from 90% to 100%. It is of particu-



lar interest to manufacturers of commercial oxygen and carbon dioxide but has many practical uses also in industrial processes. It came into being as result of demand for testing the high purity of oxygen for use in flying, etc. It is similar to standard Orsat but its technique in operation differs somewhat. It is offered in two styles—a wall mounted model for permanent installation and a portable model supplied in a neat metal case with leather carrying handle. It may be had with a single unit or with two units. A junior model ("Series EJ") is also obtainable with a burette capacity of 30cc. Smaller model measures 6¼" × 9⅝" × 3¾" and weighs, fully charged, less than 6 lbs. All models feature a new four-way valve designed to conserve space and facilitate operation.—*The Hays Corporation, Michigan City, Indiana.*

Input Transformers

New "400 Series" input transformers are intended for high quality amplifier requirements, are designed to occupy minimum space with excellent frequency response



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Our production of special clock movements and clockwork mechanisms for recording instruments must wait until this war is won. Meanwhile, we would welcome the opportunity of working with you in developing your post-war designs.

Remember, Chelsea has been making special movements for recording instruments for many years.

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Unique construction enables operator to rapidly determine temperature even on minute spots, fast moving objects, or smallest stream; no correction charts, no accessories, no maintenance expense. Special "FOUNDRY TYPE" and "Universal TRIPLE RANGE" have, in addition to standard calibrated range, a red correction scale determining TRUE SPOUT and POURING TEMPERATURES of molten iron and steel when measured in the open.

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It's a *distinguished* family, this Conant clan of instrument rectifiers. They have taken all the mystery out of the rectifier business.

Over ninety per cent of all rectifier requirements are served by 12 types—4 basic assemblies in 3 series. These 3 series are the three members of the Conant family shown above. Special types, however, can be developed as needed, and you'll find Conant ready to cooperate.

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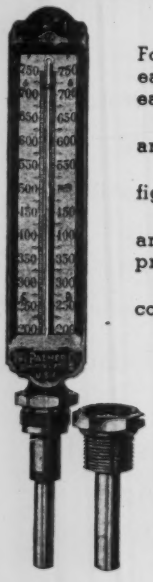


EACH ONE HAS A JOB TO DO

For MOM, who has been on the job many years, it means inspection of each Thermometer before it can be shipped and nothing gets by her eagle eye.

For RUBY, it is graduating fine lines on a waxed tube, with great care and precision for each line is important in the final accuracy.

Together they do a grand job . . . while their loved ones are away, fighting for freedom.

It's folks like these, imbued with a spirit of loyalty to our firm, who are responsible for the fine Thermometers that help you make a finer product.

Remember, in post-war plans, only GOOD Thermometers should be considered in rebuilding your future Sales.

1. **Guaranteed Accuracy.**
2. **Easy reading "Red-Reading-Mercury" feature.**
3. **Built for long life.**

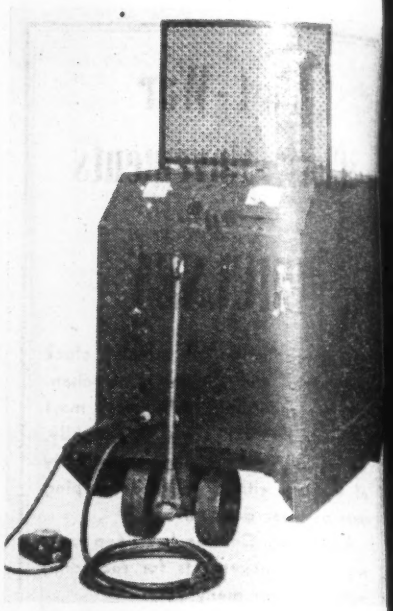
(catalog on request)

THE PALMER COMPANY

Mfrs. of Industrial, Laboratory, Dial and Recording Thermometers

2811 NORWOOD AVENUE CINCINNATI 12, (Norwood) OHIO

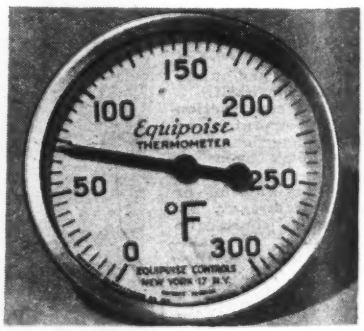
Canadian Plant: King and George Sts., Toronto



Voltmeter is arranged for a high degree of accuracy throughout complete voltage range up to 100,000 volts, at all loads and power factors, permitting precision measurement of the applied voltage. A safety foot switch which must be held down during the test instantly de-energizes the set when it is released. Another safety device is the screen guard located between high-voltage bushing and operator's working position. Complete test set is approx. 6 ft. high, 5¾ ft. long and 2½ ft. wide, can be plugged into any convenient 230-volt, 60-cycle outlet. — *General Electric Co., Schenectady 5, N. Y.*

Bimetal-element Dial Thermometer

New bimetallic dial thermometer is said to feature permanently-calibrated, highly accurate and extremely responsive precision bimetallic helical coil measuring element having case of alloy steel in most sizes, 18-8 stainless steel connection nut and stem; large, easy-reading numerals and temperature graduations on metal dial; and unbreakable, bullet-proof glass. Expansion



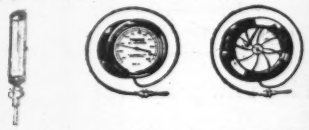
of bimetallic coil rotates attached small shaft and indicating pointer as one unit over entire scale range as the only moving part. There are no pivots, mechanical linkages or gears. Rugged construction is said to protect thermometer against corrosion, vibration, shock and rough handling and to insure long, dependable service. Various standard ranges are available between limits of —90°F. and 1000°F. Test or laboratory thermometers are graduated in both C. and F. on same scale. Over-range protection: temperature can be increased 50% or more beyond end of scale range without damage to thermometer for ranges up to 500°F., 10% over-range for ranges up to 1000°F. Thermometers are obtainable in 2",

They combine a high permeability shield with rotatable strap mounting for minimum stray field pick-up and are equipped with 10" Suprenant color-coded lead. Three types are announced. (1) "401-A Input Transformer" operating from 30/250/600 ohms primary to 30,000 ohms secondary center tapped. (2) "Type 400-C Bridging Input transformer" with a nominal impedance 600/15,000 ohms to 60,000 ohms secondary. With proper input circuits, input impedance range 0/25,000 ohms. (3) "402-A Input Transformer" with a nominal 30/120 ohms primary to 50,000 ohms secondary. Input impedance range 0/250 ohms. All types have a maximum operating level + 10 V.U. at 0.001 milliwatt reference level. Finish is baked gray enamel. 2" center-to-center mounting; 1½" O.D. × 2¼" high. — *The Langevin Company, Inc., 37 West 65th St., New York 23, N. Y.*

100,000-volt Portable A-c. Test Set

New portable self-contained 100,000-volt a-c. test set, for highly accurate testing of heavy apparatus which can not readily be moved to a stationary test berth or laboratory, has a capacity of 10 kva., is suitable for conducting tests on large high-voltage equipment such as motors, generators, circuit breakers, bushings, short lengths of cable, and other electric apparatus. Complete equipment consists of an oil-immersed step-up transformer, hand-operated induction regulator for smooth voltage control, double-scale output voltmeter, electric timing clock, overload relay with automatic reset, and a two-pole magnetic contactor. These components are enclosed in a steel housing mounted on a four-wheel truck.

TRERICE
THERMOMETERS



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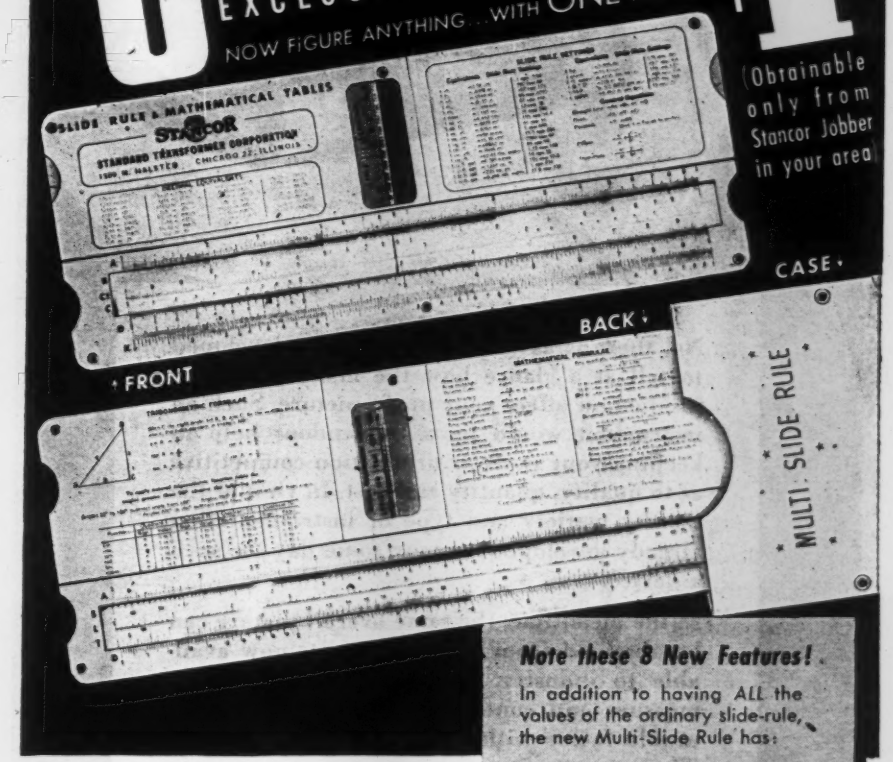
$1 (Obtainable only from Stancor Jobber in your area)



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STANCOR now offers the entire electronic industry the new Multi-Slide Rule. First developed for our own use, it is today made available to all . . . Greatly simplifies calculation of unlimited range of problems . . . A genuine professional rule—not a toy. This rule is obtainable ONLY THROUGH STANCOR JOBBERS. PLEASE DO NOT ORDER DIRECT. See your local directory for the name of the Stancor jobber in your city or, write for his name. Price of Stancor Multi-Slide Rule: One Dollar!—America's biggest slide-rule bargain—a service to the trade by Stancor.

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In addition to having ALL the values of the ordinary slide-rule, the new Multi-Slide Rule has:

1. Four-place LOGARITHM TABLE
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5. Table of SLIDE-RULE SETTINGS
6. Table of GENERAL EQUATIONS
7. Long list of common MATHEMATICAL FORMULAE
8. DECIMAL equivalents of a fraction

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STANCOR

ORDER FROM YOUR JOBBER

No, there is as yet no profit-meter developed to tell at a glance how the many factors of production affect your profit picture. Such an instrument would be a tremendous help in keeping your postwar production competitive as to quality, quantity and cost. In view of the quality, variety and type of instrumentation already developed we may some day see such a device.

In the meantime, the same overall picture can be obtained from the instruments now available to industry. There are instruments to measure and control every physically measurable factor with which you must contend. These range from simple thermometers to complex electronic instruments that control entire production processes.

Every step forward in civilized progress has been measured by instruments and instrument makers will set the pace for future progress. Make certain your own production is under the positive control of instruments—buy them, use them, rely on them, and profit from them.

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This advertisement was prepared for INSTRUMENTS by Sanger-Funnell, Inc., New York City, advertising agency for J-B-T Instruments, Inc., Certified Gauge & Instrument Corp., Cinaudagraph Corporation, Foster Engineering Co., Premier Crystal Laboratories, Inc.

3", 5" and 6" dial sizes. Easily installed by connecting ½" standard connection nut directly into point of service or into separable socket or other type of mounting accessory. Separable sockets are high-pressure type designed for universal service conditions, having 1" or ¾" standard connections. — *Equipoise Controls, 342 Madison Ave., New York 17, N. Y.*

High-megohm-value Resistors

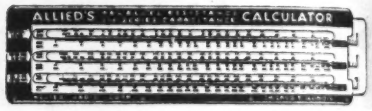
New "Hi-Meg" resistors are available in values from one megohm to 1,000,000 megohms. This resistor range is said to have been inadequately covered in the past to meet the needs of fine instrumentation, especially in electrometer applications, where low operating currents necessitate extremely high resistances of great stability. New resistors are offered in one physical size regardless of resistance value: glass envelope 3/16" diameter by 1⅞" long; leads extending 1¼". Design is said to lend itself to unusual stability with low temperature and voltage coefficients. — *Victoreen Instrument Co., 5806 Hough Ave., Cleveland 3, Ohio.*

Parallel-resistance and Series-capacitance Calculator

New Parallel-resistance and Series-capacitance Calculator is a slide-rule device designed to provide a rapid and accurate means of determining the reciprocal of the sum of two reciprocals:

$$1/x = (1/a) + (1/b)$$

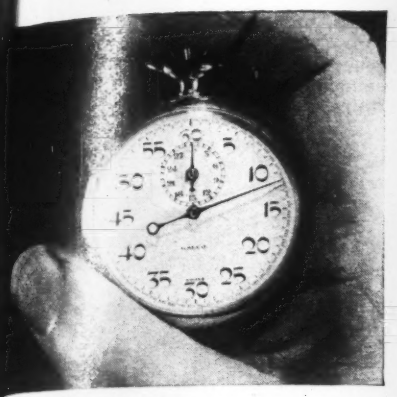
A single setting of the slide automatically aligns all pairs of a and b values which



will satisfy the equation for any given value of x. This calculator indicates in one setting the numerous pairs of resistances which may be connected in parallel, or capacitances in series, to provide any required resistance or capacitance value. (Range: 1 ohm to 10 megohms; 10 mmfd. to 10 mfd.) However, capacitance and resistance figures on face of rule can just as well serve to represent inductance, impedance, reactance, or other units which can be handled in a similar manner. Thus, calculator becomes equally valuable in solving problems involving inductance in parallel, coupled inductance, numerical magnitude of impedance, parallel reactance, etc.—*Allied Radio Corp., 833 West Jackson Blvd., Chicago 7, Illinois.*

High-vacuum Recorder

New "Vacorder" is a McLeod type recording gage for producing a continuous, visible record of pressure conditions within a vacuum system, between the limits of 1 and 5000 microns absolute pressure. Equipment consists of a modified "Stokes High Vacuum Gage," calibrated in microns, combined with a galvanometer type recording unit. Gage is mechanically tilted from horizontal (normal) position to the vertical (reading) position by an electric motor. Height of measur-



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1/5 second timers and decimal timers (minute divided into 100 parts).

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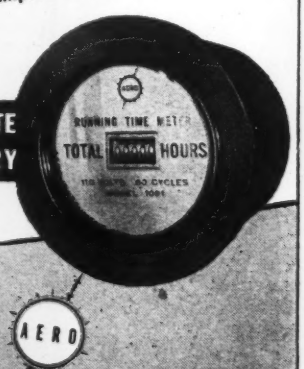

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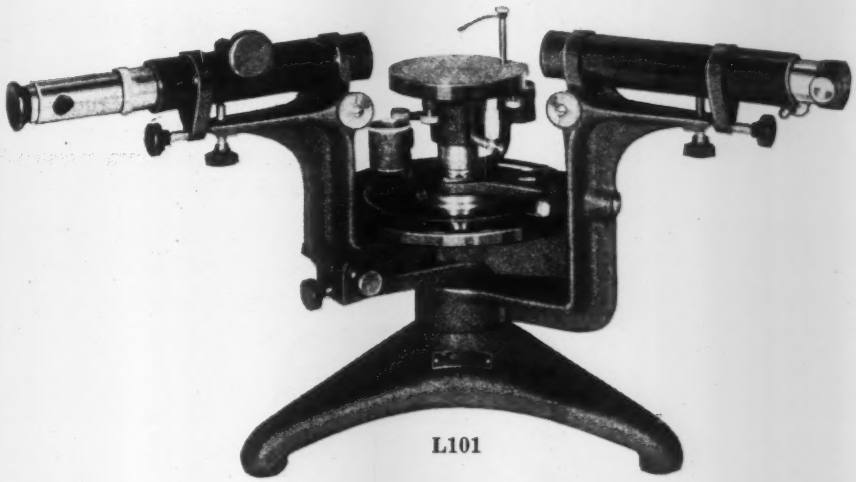

L101

A rugged versatile instrument used by industrial laboratories for rapid qualitative determination of compounds, checking of prisms, index of refraction, dispersion, resolving power as well as other fields of investigation utilizing the various accessories which include polarizing and camera attachments, diffraction gratings, Babinet Compensator and others.

This instrument incorporates many features found only in the more expensive spectrometers.

Readings can be made to 1 minute; the telescope and collimator have objectives of 25mm aperture and 160mm f.1. The telescope is provided with rack and pinion focusing and 10X Gauss Eyepiece; a bilateral slit with stainless steel jaws 10 mm long is provided with the collimator.

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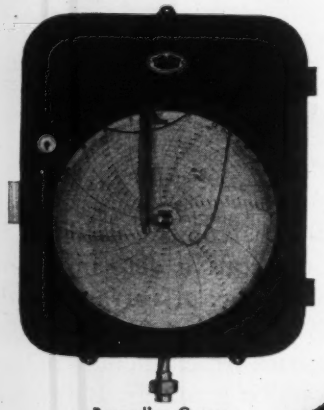

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DIAL INDICATING CASES:
PHENOL CONDENSATE
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DIAL SIZES: 3½", 4½", 6" and 8½"
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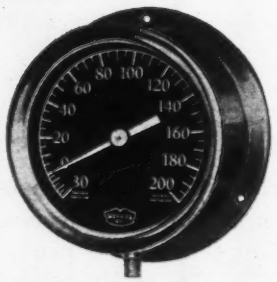
Your inquiries as to WEKSLER GAUGES—types of movements, connections, list prices, etc., are solicited. The helpful advice of our Engineering Department is yours for the asking.



Compound Gauge, Cast Brass Case

WEKSLER THERMOMETER CORP.
52-56 West Houston Street
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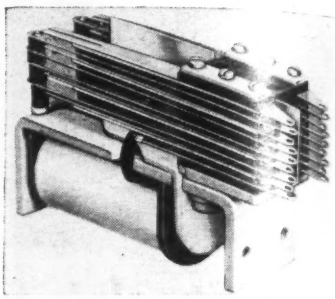
ing capillary, and hence vacuum in system, is electrically determined, this reading being automatically transmitted to the recorder. Recording unit may be located at any distant point, but instrument proper is installed preferably close to sampling point. A similar "Vacorder" instrument, with one recording unit and as many as four indicating instruments, is available, to record pressure in sequence on a strip chart. Gages are true McLeod type instruments similar to the portable indicating gages (Stokes patent) which have been in general use for a number of years; but this is the first time such gages have been combined with a recording unit. They are designed for hard, continuous service, with a built-in chemical trap which excludes gases and all condensable vapors, including water, oils and alcohol, and assures accurate readings under all conditions. —*F. J. Stokes Machine Co., Philadelphia 20, Pa.*

Capacitors with Specified Temperature Coefficients

New Tubular Ceramic Capacitors can be supplied in any desired temperature coefficient between +120 and —4000 parts per million per degree Centigrade. Of this total temperature range, the portion from —750 to —4000 parts per million is new and has the same accuracy of temperature compensation curve and uniform electrical characteristics as the present standard ranges. New ceramic bodies have somewhat higher dielectric constants and thus provide higher values of capacitance on the same size tube. They are not to be confused, however, with the so-called "Hi-K" or high dielectric bodies that have still higher dielectric constants but less uniform characteristics. —*Centralab, 900 E. Keefe Ave., Milwaukee, Wis.*

Multi-contact Relay

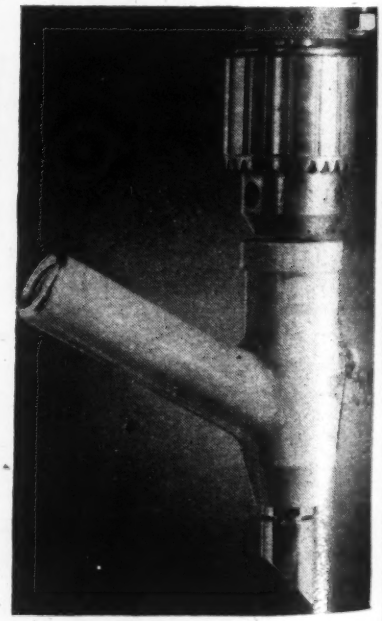
New "Type 20000" long- relay is especially applicable to signa electronic and communication uses, where minimum operating currents are importa factors. Con-



tact spring assemblies of this relay can be furnished in one, two, or three stacks with various combinations, according to circuit requirements, up to 16 springs. Coils, specially treated to withstand extreme humidity and prevent fungus growth, are available in voltage ranges from 1½ to 28 volts d.c. This type of relay is also available in two-pole double-throw contact arrangement with current-sensitive coil operating at 3.2 milliamps. pickup and 1 to 1.5 milliamps. dropout. These relays are available with quick-acting slow-dropout and slow pick-up armatures. "Type 20000" relays are produced in two sizes: standard, 4¾" long, 1" wide, and approximately 1⅝" to 2½" high depending upon contact spring assembly; intermediate, 3⅝" long, 1" wide, and 1¾" to 2½" high depending upon contact spring assembly.—*R-B-M Mfg. Co. Division of Essex Wire Corp., Logansport, Indiana.*

Centering 'Scope

New "Center Scope" is an optical locating and centering microscope molded of gray Tenite plastic, designed to locate or center edges, lines, or punch marks on a workpiece to the spindle axis of any machine tool, also suitable for measuring dimensions inaccessible to mechanical devices, for checking and inspection work, etc. Since optical lighting is not subject to errors such as pressure, wear, temperature, and human variations, accurate work may be produced in a minimum time, and operator need have no technical knowledge or training. "Center Scope" is injection-molded of Tenite in four pieces. Mold is so designed that



WHEATSTONE BRIDGE

Rubicon Wheatstone and Kelvin Bridges are available in a number of types to suit various applications. All are made in accordance with the highest traditions of the instrument maker's art and are fully guaranteed.

Described in Bulletin 100 which also lists Rubicon Resistance Boxes and Shunts as well as NBS and Reichsanstalt Resistance Standards.

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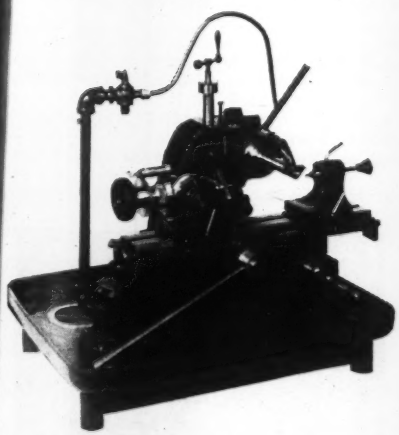

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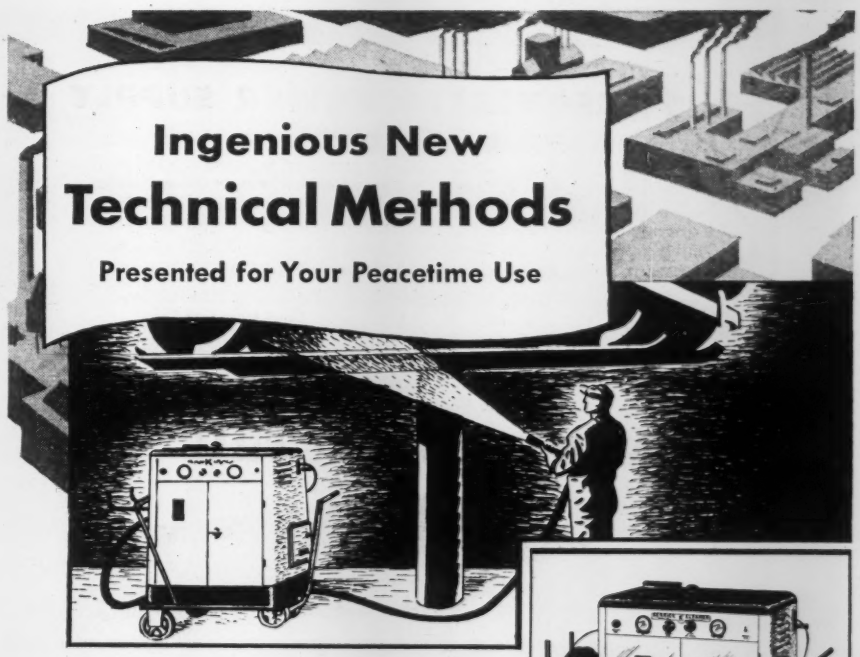

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80% SAVINGS IN CLEANING TIME

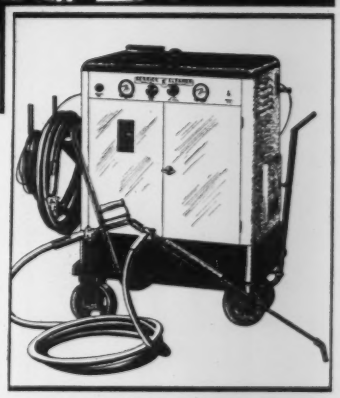
With Steam Rig Now the Army's Standby

An economical solution to the problem of cleaning and degreasing trucks, passenger cars, tractors, locomotives, excavators, and the like will be available to garages, service stations, all users of oil-burning equipment, as soon as war demands permit. It is a more efficient steam cleaner now in use by the thousands in the Armed Forces.

Neat "housekeeping" has too often been neglected by industry due to the costliness of hand labor. But the best housekeepers in the World, the U. S. Army, Navy and Marine Corps, dare not neglect frequent and thorough cleaning of all equipment to safeguard against fire and malfunctioning, and to permit fast, certain inspection. This cleaner, developed to meet their high standards, removes grease, dirt and grit 5 times as fast as any other method. It cleans by a balanced combination of heat, detergent, water and friction. It is typically "army" in simplicity of design and operation; in 30 minutes, the entire machine can be dismantled and completely cleaned.

Wartime uses of Wrigley's Spearmint Gum also point the way that industry may benefit when this quality product again becomes available. It will *again* be a "help on the job" in many ways. Right now *no* Wrigley's Spearmint is being made, as present conditions do not permit the manufacture of Wrigley's Spearmint in quantity and quality sufficient for all. But remember the Wrigley's Spearmint wrapper—it is a certificate of highest quality and flavor—and will always remain just that.

You can get complete information from Clayton Manufacturing Company, Alhambra, Calif.



The Kerrick Kleaner

Remember this wrapper

Z-74

To the Instrument Man With IDEAS

IF you have designs or patents for post-war production and sales, the Post-War Product Service of The Instruments Publishing Company will gladly put you in touch with interested companies manufacturing instruments and devices for measurement, inspection, testing and control.

Write to Post-War Products Service, Instruments Publishing Company, Pittsburgh 12, Penna., giving a brief description of your idea, so that this Service may refer it to the interested companies.

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250-450 VOLTS

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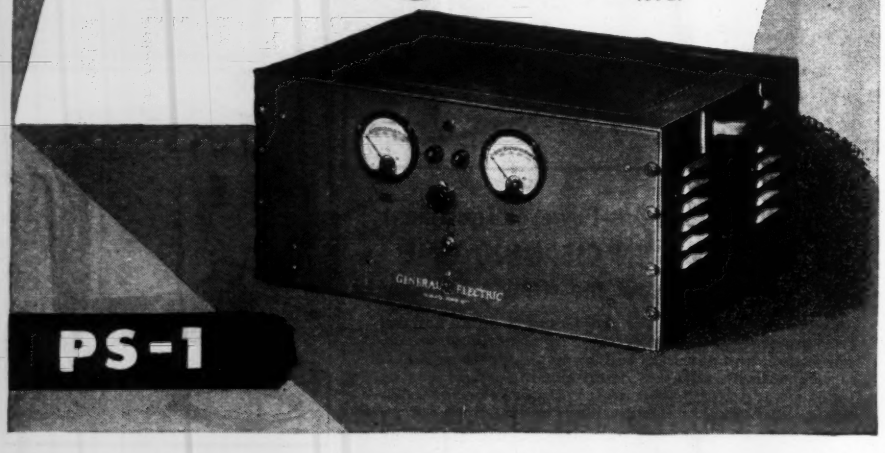
Other G-E regulated power-supplies are available in the following ranges: **180-300 volts 160-1500 volts Dual Regulated**

Write today: Electronics Department, Specialty Division, General Electric, Syracuse, N. Y.

Electronic Measuring Instruments

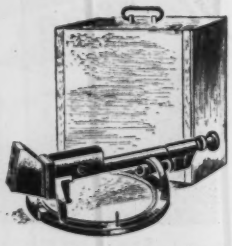
GENERAL ELECTRIC

164-D1



PS-1

Telescopic Alidade



With lighthouses blacked out, shore lights dimmed, familiar landmarks lost, a ship's navigator needed a reliable new device to take bearings.

Kollmorgen produced a telescopic alidade of precision craftsmanship for the U.S. Navy. The instrument mounts over the ship's compass, has a trisected field showing simultaneously 1) object viewed, 2) compass indication, 3) level vial. Designed for both terrestrial and celestial observation, the alidade has a prism attachment for measuring angles of heavenly objects, and in checking intersections of two azimuth circles at intervals. Light weight, accurate, easy to operate, it is but one of many optical devices of extreme accuracy made by Kollmorgen, leading producer of submarine periscopes.

When peace comes, Kollmorgen technicians accustomed to tolerances of millionths, will welcome new assignments in development and manufacture. Inquiries invited—now!

KOLLMORGEN OPTICAL CORP.

2 Franklin Avenue Brooklyn 11, N.Y.

bond lines appear on any of the pieces. The Tenite used is a cellulose acetate butyrate product of Tennessee Eastman Co., Kingsport, Tenn. A special formula Tenite which responds very little to temperature changes the instrument may be counter is used.—*Center Scope Products, Glendale, Calif.*

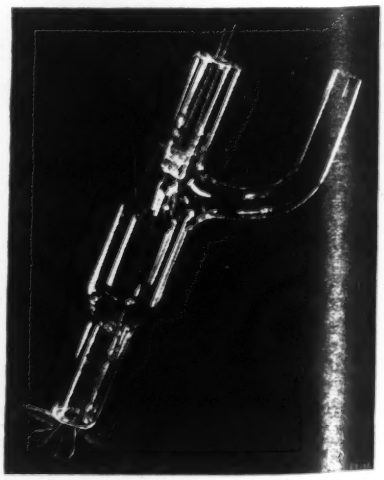
Tube Tester

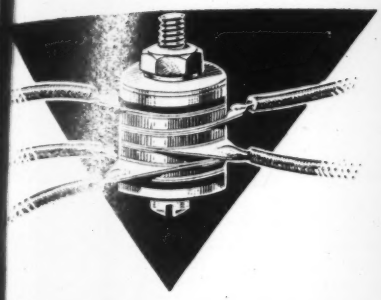
New "Model 450" tests all tubes up 117 volts as well as pilot lights (sockets).; employs emission method for testing tube quality (directly read on

indicating instrument); tests shorts and leakages up to 3 megohms in all tubes tests shorts and leakages of any one element against all elements in all tubes tests both plates in rectifiers; tests individual sections (such as triodes, etc.) multi-purpose tubes. For noise test, jacks for plugging in either phones or amplifier will detect microphonic tubes or poor due to faulty elements or loose internal connections. Tester operates on 90 to 1 volts, 60 cycles. Size 13" × 12" × 6"; weight 8 lbs. — *Superior Instruments Co., 227 Fulton St., New York 7, N. Y.*

Ionization Gage

New "Type E-31 Precision-Televac" ultra vacuum gage is said to be the result of years of research to eliminate deficiencies usually associated with this type gage. Electrical leakage is completely eliminated and, when used with a moderately high speed pumping system, this ionization gage actually outgasses itself. Filament is protected before and during operation automatically in that current will not enter filament before pressure of 1 micron has been established and turns off automatically if pressure rises above 1 micron. Gages are interchangeable without recalibration and





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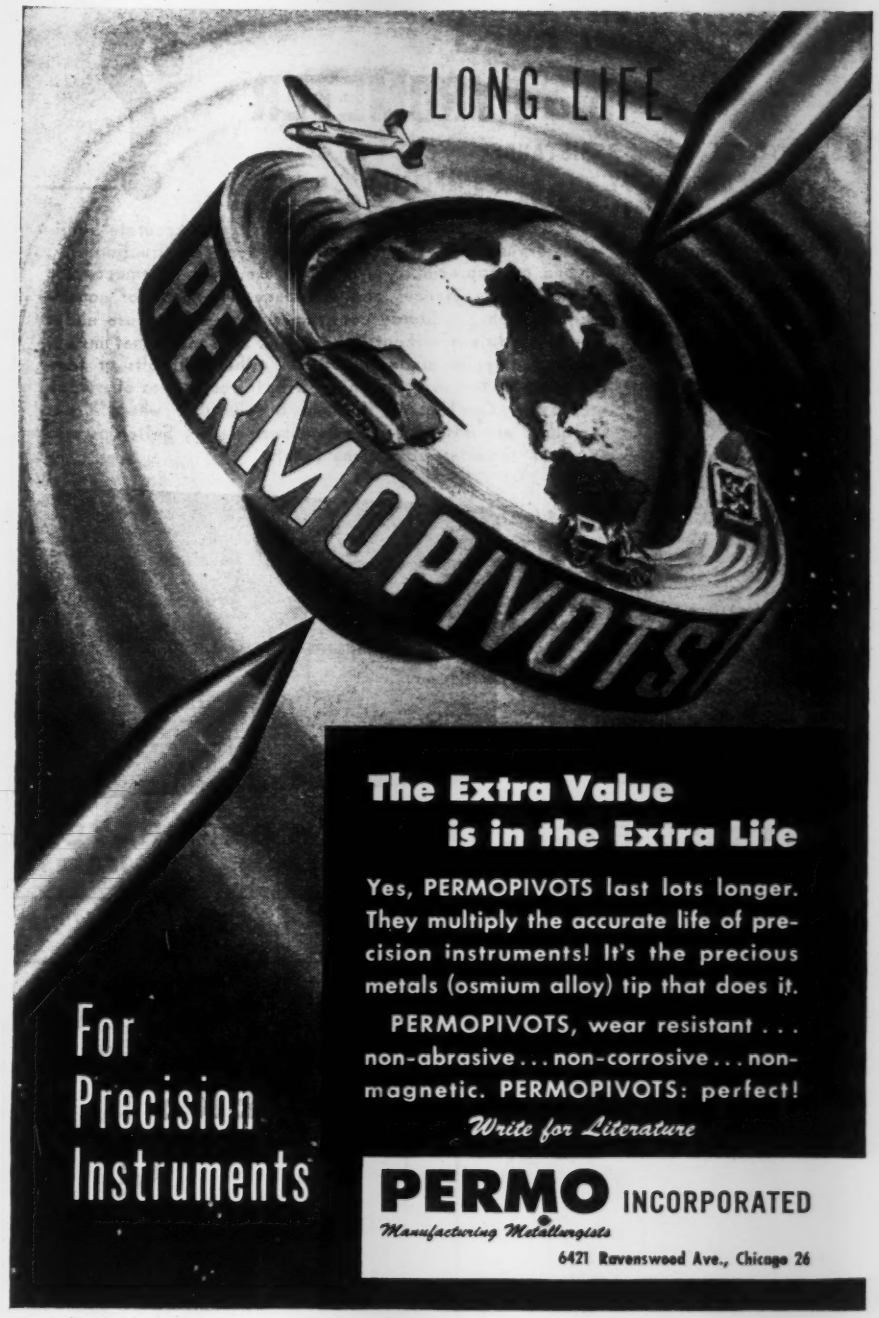

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For Precision Instruments

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MAINTENANCE AND SERVICING OF ELECTRICAL INSTRUMENTS

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SHOULD be of great value to all those whose problem is to keep in operation the electrical instruments on vital war production as well as on war equipment.

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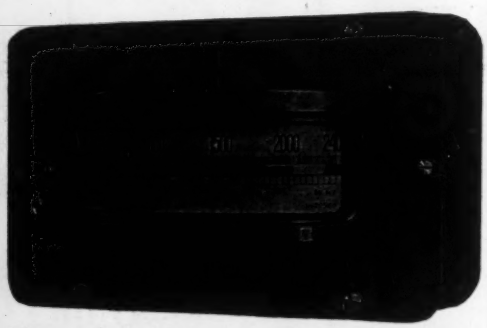
WALL TYPE W-1



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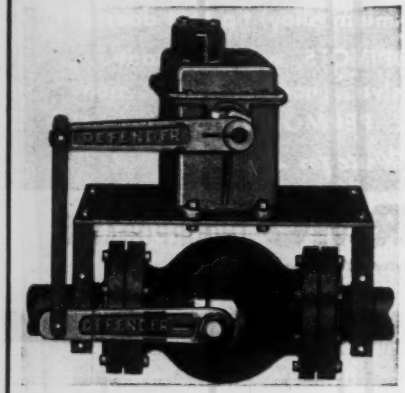
90 CHESTNUT ST. NEWARK, NEW JERSEY



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The longest lived Valve made for Hot Water or Steam or any other Chemical or Fluids or Oils

It can be hand operated or Motor operated as illustrated and we have a complete line of both Low and medium and High pressure stats and also Temperature. Float. Liquid level and Feed Water Regulator stats shown in our new Bulletin No. E-3 and E-4. Write for same.

Defender Instrument & Regulator Co.
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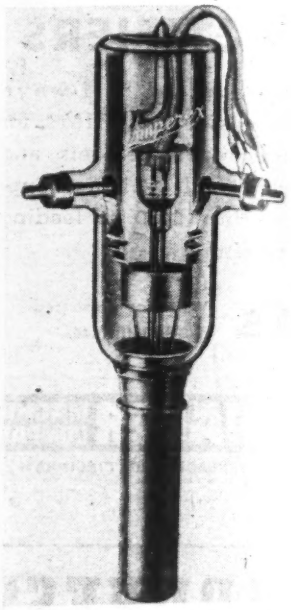
48 Van Sinderen Ave., Brooklyn, N. Y.

guaranteed for 1000 hours. Standard E-11 ionization gage comes on scale at 0.4 micron (4 × 10-4mm Hg). New ionization gage is used with "Televac Type S" recorder (see *Instruments*, April 1945, page 272.)—*Precision Scientific Co., 1750 N. Springfield Ave., Chicago 47, Ill.*

33-kw. Amplifier or Oscillator Tube

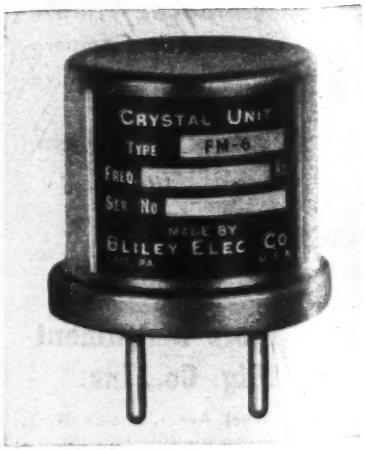
New "Amperex 233" is especially suited for use as a Class C oscillator or amplifier for generating radio-frequency power at frequencies up to 30 Mc. Use of two grid arms makes neutralization more convenient in the amplifier connection, also permits cooler operation of the grid when the tube is used at the higher frequencies either in a self-excited oscillator or power amplifier.



General characteristics:—Filament voltage, 24 volts; filament current, 70 amperes; Thermionic emission, 16 amperes; Amplification factor, 62; Direct interelectrode capacitance: grid to plate, 24 $\mu\mu$f, grid to filament, 22 $\mu\mu$f, plate to filament, 1.5 $\mu\mu$f. Maximum d-c. plate voltage, 15,000; maximum d-c. grid current, approx. 500 amperes. Tube length (not including flexible leads) 21"—*Amperex Electronic Corp., Inc., 79 Washington St., Brooklyn 1, N. Y.*

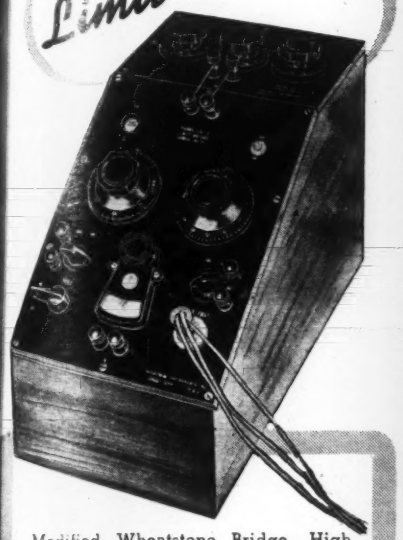
Low-frequency Crystal Oscillator

New "FM6" low-frequency crystal unit will maintain its frequency "within considerably narrower limits than were heretofore obtainable," employs a resonant pin



HIGH-SPEED PRODUCTION TESTING . . . .

Resistance Limit Bridge



Modified Wheatstone Bridge. High and Low limit dials. Continuously variable. Any tolerance between 0 to 30% low, 0 to 40% high.

Sensitive galvanometer provides indication. Guaranteed accuracy plus/minus 1% of standard, Model LB-3, .1%.

Resistance decade at rear of cabinet. Can also be used with external standards. Checks resistors between 1 ohm and 3 megohms.

Entirely self-contained. Furnished complete, ready to operate. AC operated. 15" x 6" x 10" h.

• The up-to-date way to test resistance values for given tolerances, on the busy production line. Negligible setup time. Great flexibility. Wide-range accuracy. High-speed operation. Extremely rugged. Can be operated by anyone. Typically an "Industrial Instrument" which soon pays for itself in production time saved.

• Write for Bulletin . . .

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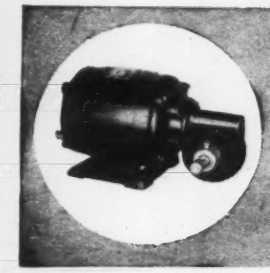
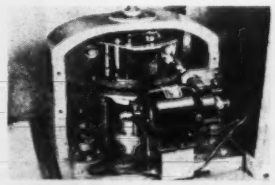


PRECISION MOTORS for important instrument applications

The delicate mechanism that automatically guides the solar coronagraph at the Fremont Pass Station of Harvard College Observatory is driven by a Bodine universal speed reducer motor.

TYPICAL APPLICATION

Bodine universal motors have high starting torque, good efficiency, high output, and extreme ruggedness. In the application below, the speed reducer is an integral part of the motor.



Building fine small precision motors is an art that requires skilled hands, quality materials, and the "know how" that comes only through long years of experience in that field. These are good reasons why Bodine fractional horsepower motors are logical choices for your motor-driven precision instruments.

Bodine also makes motor selection simple by providing over 3,000 standard specification motors available to meet a wide range of space and rating requirements. The Bodine engineering service is at your disposal for proper motor selection and application. Bodine Electric Company, 2244 W. Ohio St., Chicago 12, Ill.

BODINE FRACTIONAL HORSEPOWER MOTORS

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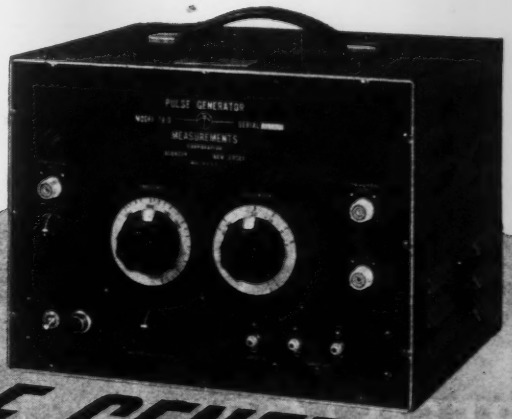

PULSE GENERATOR

MODEL 79-B

SPECIFICATIONS:

FREQUENCY: continuously variable 60 to 100,000 cycles.
PULSE WIDTH: continuously variable 0.5 to 40 microseconds.
OUTPUT VOLTAGE: Approximately 150 volts positive.
OUTPUT IMPEDANCE: 6Y6G cathode follower with 1000 ohm load.
R. F. MODULATOR: Built-in carrier modulator applies pulse modulation to any r.f. carrier below 100 mc.
MISCELLANEOUS: Displaced sync output, individually calibrated frequency and pulse width dials, 117 volt, 40-60 cycles operation, size 14"x10"x10", wt. 31 lbs.

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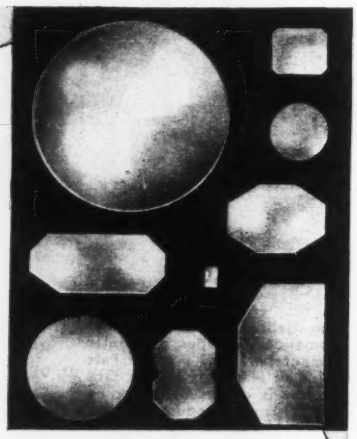

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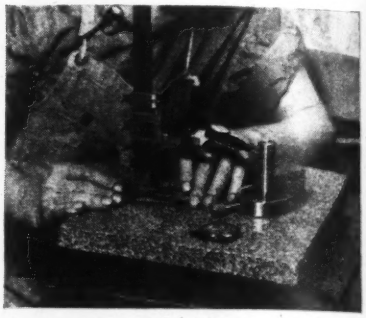
assembly. Steel pins are mechanically resonant to the crystal frequency or some multiple thereof, so that any clamping effect of the clamping pins is negligible. Internal assembly is protected against moisture and humidity by captive gasket seal between aluminum shell and laminated phenolic base. "FM6" is intended for such applications as frequency standards, timing measuring equipment, frequency meters, carrier current and other applications where an accurate source of low frequency is required.—*Bliley Electric Co., Erie, Pa.*

Granite Surface Plates

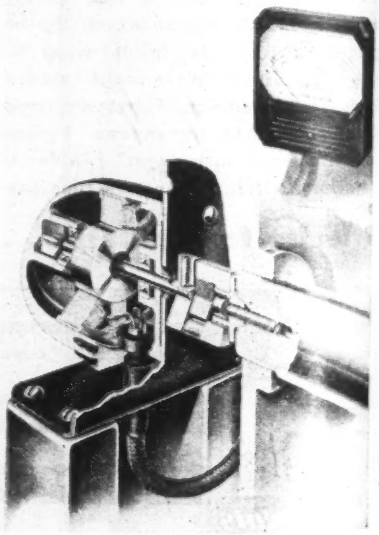
New granite surface plates makes possible accuracy to 0.0001" when gaging points, laying out drill jigs, dies and fixtures, are made of Vermont granite, ground



and lapped to precise tolerances. Having been aged in the ground for many thousands of years, all internal stresses have been relieved, making it non-warping. Plates cannot be damaged seriously as nicks or scratches will not raise a burr and impair accuracy. Granite having a low coefficient of friction, tools and fixtures can be moved with ease. Granite need not be protected against corrosion. Being non-magnetic, it will not attract and hold iron chips or dust. "Ideal Granite Surface Plates" are available in a wide range of sizes from 8"×10" to 30"× 72" (larger sizes available on application). All plates are of uniform cross section and will not change shape or accuracy with variations in temperature, or with age. Price depends upon accuracy desired.—*Ideal Commutator Dresser Co., 1060 Park Ave., Sycamore, Ill.*

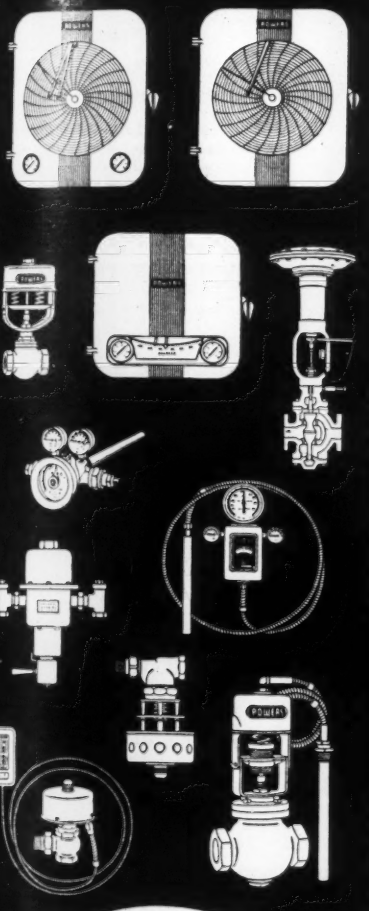
Electric Tachometer

New "Reliance Electric Speed Indicator" consists of two units; pickup unit, a miniature six-pole alternator with a permanent-magnet rotor, is mounted on shaft whose speed is to be measured; indicator, a permanent-magnet moving-coil type, indicates



POWERS

TEMPERATURE and HUMIDITY CONTROL



When you want accurate and dependable automatic temperature or humidity control for Industrial Processes, Heating or Air Conditioning Systems, call in a Powers engineer. With over 50 years of experience and a very complete line of self-operating and air operated controls we are well equipped to fill your requirements.

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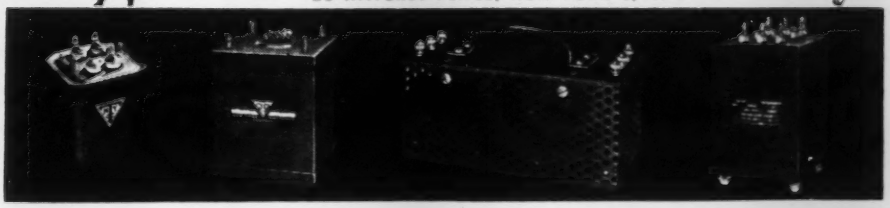

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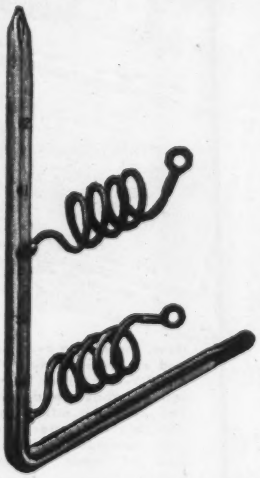


● Sensitivity of a hundredth of a degree is easily attainable. ● Top of mercury column visible at control point (where most important) because electrodes terminate at back of tube. No encircling metal bands! ● Available in angle form (illustrated) or conventional straight form. ● Send for brief, attractive bulletin.

The Philadelphia Thermometer Co.
Sixth & Cayuga Sts. -:- Philadelphia
Oldest Thermometer Manufacturer in Philadelphia

pick-up output on a 3¾" scale which covers 95° of arc. Resistance of indicator has been made sufficiently high, so that size or length of leads connecting the units will have no effect on accuracy, and indicator may be located at "any distance" from pick-up unit. It is claimed that indicator is not affected by other magnetic material and that there is no loss of accuracy due to length of service. Instantaneous and continuous speed indication is independent of direction of rotation of shaft. Pick-up windings are stationary, and there are no commutators or slip rings. No conduits are required, and lifetime lubrication further simplifies maintenance. Special attention to flexibility of use has been given in physical design of indicator. Fool-proof shaft coupling is provided, and indicator may be bracket or panel mounted. Indicators are provided for full-scale deflection corresponding to 1500, 2000, 2500, 3000, and 5000 r.p.m. and special scales are available to read in other units, such as feet per minute, and process cycles of varying times.—*Reliance Electric & Engineering Co., Cleveland, Ohio.*

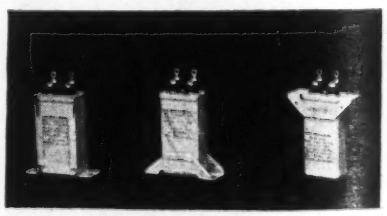
Volume Level Indicator

New "Type 920 Volume Level Indicator" for low-level indication is designed primarily for use across balanced lines, also permits either side of bridged lines to be grounded. Unit is mounted on a panel for use in standard relay rack. It comprises a

copper-oxide type indicator adjusted for deliberate pointer action, a zero-adjusting control and heavy-duty range control variable in steps of 2 VU, 100 to 130 volt 60 cycle a-c. power supply with voltage regulator to adjust for normal supply variations. Specifications.—Range: −20 to + 20VU at 0 VU reading; Extreme range: −40 to +23VU, including full scale; Standard reference level: 1 mw. into 600 ohms; Variation with frequency: less than 0.2db between 30 and 15,000 cycles.—*The Daven Company of 191 Central Avenue, Newark, N. J.*

Fixed Paper-dielectric Capacitors with Glass Terminal Seals

New line of hermetically-sealed fixed paper-dielectric capacitors with glass terminal insulators, in case styles CP-60, -62, and -64, characteristics E and F, meet rigid



requirements of the Proposed JAN-C-25; are suitable for use in combat communication equipment where severe operating conditions may be encountered. Glass terminal seals provide unusually high degree of resistance to humidity, fungus growths and termites. They are of a new and unique construction which does not rely on matched coefficients of expansion of glass and metal to resist thermal shock, nor on soft solder for mechanical strength. All three case styles are available in all proposed JAN-C-25 ratings, in both single-section and two-section construction. Capacitance values range from 0.05 to 0.50 microfarads for voltages of 600, 1000, or 1500 volts.—*General Electric Co., Schenectady 5, N. Y.*

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Type 140-A

A dependable test instrument

An accurate signal source capable of supplying a wide range of frequencies and voltages.

Frequency Range 20 C.P.S. to 5 MC.
Output Voltage 1 mv to 32 volts.
Power Output 1 watt.

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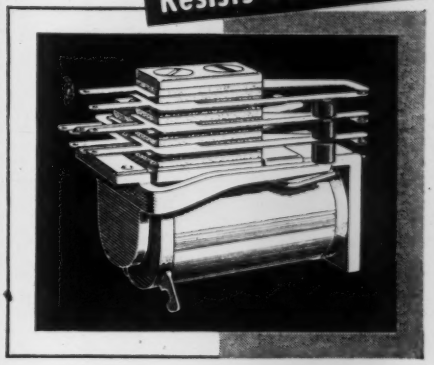
CLARE

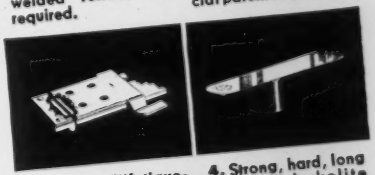
...Type "K" Relay Resists Vibration



Clare Type "K" Relay, originally designed for aircraft use, has special advantages for applications requiring extremely small size, light weight and unusual resistance to vibration. Armature is held by a special reed type armature bearing made of heat-treated beryllium copper which is practically fatigueless—no anti-vibration springs necessary. Short contact springs are vibration-resistant. Overall dimensions are 1½" x 1¼" x 1-13/16"; weight, approximately 1⅔ ounces. Like all Clare Relays, Type "K" can be "custom-built" to meet unusual requirements. These five features are good reasons for specifying Clare Type "K" Relays in your instrument applications:

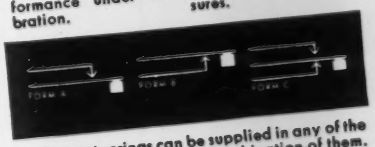
1. Armature assembly, single or double arm; stainless steel shaft; adjustable or welded residual as required.

2. Nickel silver springs to which contacts of silver or of palladium are overall welded by a special patented process.



3. Hinge of "fatigueless" beryllium copper insures long life and accurate performance under vibration.

4. Strong, hard, long wearing bakelite bushing insulators resist vibration and heavy contact pressures.



5. Contact springs can be supplied in any of the three forms shown, or any combination of them.

Let Clare engineers "custom-build" a relay to your requirements. Write for catalog and data book. C. P. Clare and Co., 4719 Sunnyside Ave., Chicago 30, Illinois. Sales engineers in all principal cities. Cable address: CLARELAY.

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Instrument Societies

BALTIMORE

The final meeting of the year of the Baltimore Industrial Instrumentation Society was held on June 15. The U. S. Weather Bureau of Washington, D. C. gave an interesting discussion on Meteorological Instruments. This was given by Mr. William R. Thickston together with three assistants in his Department.

The following officers were elected for the new year: President: Mr. Fred Pullen, c/o Fuel Division, Bethlehem Steel Co., Sparrows Point 19, Maryland. Vice President: Mr. E. S. Reisler; Secretary: Mr. Franklyn Ragan (same address as president); Treasurer: Mr. Richard Post; Sgt. at Arms: Mr. Byron Dewey.

Council Members: Mr. Howard L. Halstead, Mr. Earland F. Heden, Mr. Galen E. Clark.

Our new president, Mr. Pullen, has been most active in the local organization, having served first as secretary then as treasurer and as a Council Member. We are looking forward to a successful year under his leadership.

—ELMER A. RHODES, *President, 1944-45*

FORT WORTH

The Fort Worth Electronic Club concluded this season's activities with our June meeting at which Mr. J. L. Caudry of the Texas Electric Service Company, Fort Worth, Texas, gave us an interesting talk on "High-frequency Heating."

We have also had our election of officers with the following results: President: Roy P. Bates (Texas Electric Service Co.); Vice President: Paul G. See (Consolidated Vultee Aircraft Corp.); Secretary-Treasurer: W. H. Farrington (Texas Electric Service Co.); Directors: Wendell C. Fowler (Sangamo Electric Co.); H. F. Spreen (Texas Electric Service Co.); M. M. Barnard (Fort Worth Transit Co.); J. L. Caudry (Texas Electric Service Co.); C. E. Cranford (American Manufacturing Co.).

After the close of the meeting a reel of sound film was shown to members and their guests through the courtesy of the General Electric Company on "Sight-seeing at Home."

We will resume our club activities on September 20, 1945. The programs for the coming year to be announced at a later date.

—W. H. FARRINGTON, *Secretary-Treasurer*

LOS ANGELES

The June meeting of the California Instrument Society was held Tuesday evening, June 5th, at Melody Lane, 5351 Wilshire Boulevard, Los Angeles.

The dinner was attended by sixty-eight, with eighty-two present for the technical and business session.

Dr. Wilson, of the California Institute of Technology, gave a brief history of the rocket as used in warfare, and outlined its advantages in modern warfare as compared with artillery, such as the rocket's having no recoil and the value of its spray effect, due to its greater inaccuracy, against beach defenses. He pointed out, however, that when forward launched from planes the rocket has an accuracy almost comparable to artillery due to greater launching trajectory. A Kodachrome film was then shown of firing tests with rockets from launching vehicles, boats and planes.

Following the showing of the film Mr. Richard Leitner, of Frank Reiber, Inc., gave a talk on "Applications of Geophysical Sonic Methods to Military Sound Ranging." The talk was illustrated by many [illegible] which covered the use of geophones, oscillographs and specially developed equipment.

There is no meeting scheduled for the months of July and August. The date and program for the September session will be announced later.

—M. D. PUGH, *Secretary*

INSTRUMENT SOCIETY of AMERICA

President *pro tem:* Albert F. Sperry, 225 N. Michigan Ave., Chicago, Ill.

Vice President *pro tem:* Professor Carl Kayan, Columbia University, New York City.

Treasurer *pro tem:* Clarke E. Fry, 2331 Meadow Drive, Pittsburgh 21, Penna.

Secretary *pro tem:* Richard Rimbach, 1117 Wolfendale St., Pittsburgh 12, Penna.

For Committees see May issue of *Instruments*, pages 296-297.

NEWARK

The June 5 meeting of the Society for Measurement and Control (N. J.) was opened by our new President, Mr. R. F. Roberts, who introduced the officers and committee chairman for the 1945-46 season to the Society. We were then afforded an unusual pleasure in the brief remarks of a guest, Mr. E. B. Moss from London, England. He described the long-felt need for an industrial instrument society there, and told of the recent formation of such a group. After their first meeting they received over 500 applications for membership; rather convincing evidence that they really wanted a society.

The formal meeting, a Symposium on Self-actuated Regulators was opened with Mr. G. G. Harrison, of Powers Regulator Company, talking on temperature devices. Mr. Harrison and the other speakers also, illustrated their talks with slides. He described the basic characteristics of such regulators and told of their application and limitations.

Mr. Paul A. Elfers of the Fisher Governor Company of Marshalltown, Iowa, carried the torch for self-actuated pressure regulators. He described not only how they work, but also presented engineering details and operating characteristic curves.

Mr. Thomas L. Smith of H. Belfield & Company told us all about float-operated liquid level controllers. Through his slides he enlightened us on floats, levers, stuffing boxes, bearings and all the other details pertinent to self-actuated level controls.

The meeting was preceded by a well-attended dinner. Some 40 members and over 35 guests were at the meeting.

—H. S. CLOSE, *Secretary*

NEW YORK

The 29th meeting of the New York Society for Measurement and Control was held on May 29th at the Men's Faculty Club, Columbia University, 400 West 117th St., New York City.

A report on the organization of the Instrument Society of America was presented by delegates C. O. Fairchild and C. F. Kayan.

About sixty members and guests had arrived by the time Technical Chairman Fleming presented Dr. C. M. Worstall, Consultant, who spoke on "Gas Analysis."

The thirtieth meeting, held on June 25th, at the Men's Faculty Club, Columbia University, was attended by fifty members and guests.

To increase our mailing list for purposes of increasing membership, R. K. Farnham, Chairman of the Membership Committee, passed out cards and asked each member to write down names and addresses of prospects.

Following the business session, Mr. V. R. Kimball, Eclipse-Pioneer Div., Bendix Aviation Corp., Teterboro, New Jersey, gave a very interesting analysis of "The Air Position Indicator".

—H. L. HILDENBRAND, *Secretary*

WYANDOTTE

The June meeting of the Instrument Society of Wayne County was held at Sibley Gardens. There was a fine chicken dinner followed by a brief business meeting with news and announcements. Our secretary, Mr. McCloskey having resigned, Mr. Wilson Fox was appointed to take his place.

The program consisted of talks on flowmeters by four members of our group. Mr. Russell Cushing spoke on the general subject, outlining means of metering gases and liquids. Mr. Wells Stanley spoke on derivation of flow formulae and calculation of orifices and presented the members with blueprints of data, curves and diagrams. Mr. Wm. Baker spoke on some difficult applications and your correspondent on installation and maintenance. After each talk other members were invited to ask questions and make comments.

It was a very successful meeting. We brought out some new ideas and emphasized some old ones.

—JOHN MACPHERSON, *Vice-President*

SOUTHERN CALIFORNIA METER ASSOCIATION

At the regular monthly meeting, June 21, 1945, the following were elected as officers and committee chairmen of the Southern California Meter Association: President: C. L. Hutchings (Tidewater-Associated Oil Co.); Vice President: Lee Cheever (Southern Counties Gas Co.); Treasurer: C. G. Cortelyou (General Petroleum Corp.); Secretary: Geo. H. Forster, Jr. (Texas Co.); Past-President: Mark [illegible] (Chanslor Canfield Midway Oil Co.).

Chairmen of Committees: [illegible] R. N. Christiansen (Southern California Gas Co.); Membership: Art. J. [illegible] (Southern California Gas Co.); Standards: W. L. Cowan (Union Oil Co.); Publicity: Charles Mariam (The Mariam Instrument Co.); Entertainment: George [illegible] (Pacific Meter Works); By-Laws: W. J. Kennedy (Southern California Gas Co.); Instrumentation: J. C. [illegible] (Shell Oil Co.); San Joaquin [illegible] (The Texas Co.).

In addition to the election of officers and committee [illegible] June meeting presented the [illegible] Annual Law-Jinks. Over two hundred and sixty members and guests were present at the dinner and show making this Law-Jinks the successful social function that it always has been and a fitting wind up of a very successful year for the Association under the guidance of the retiring officers.

The next regular meeting will be held at the [illegible] Hondo Arms, Friday, July 13, 1945. The two papers to be presented are "The Measurement of Solids in a ICC Plant" and "The Measurement of Solids in a Fluid Catalytic Cracking Plant." Mr. A. R. [illegible]ley, Process Division, Union Oil Co., Wilmington Refinery, and George Lewis, The Texas Co., Wilmington Refinery, will present these papers and lead the discussion.

These papers will give details of problems related to the measurement of solid flow [illegible] etc., as exemplified in the

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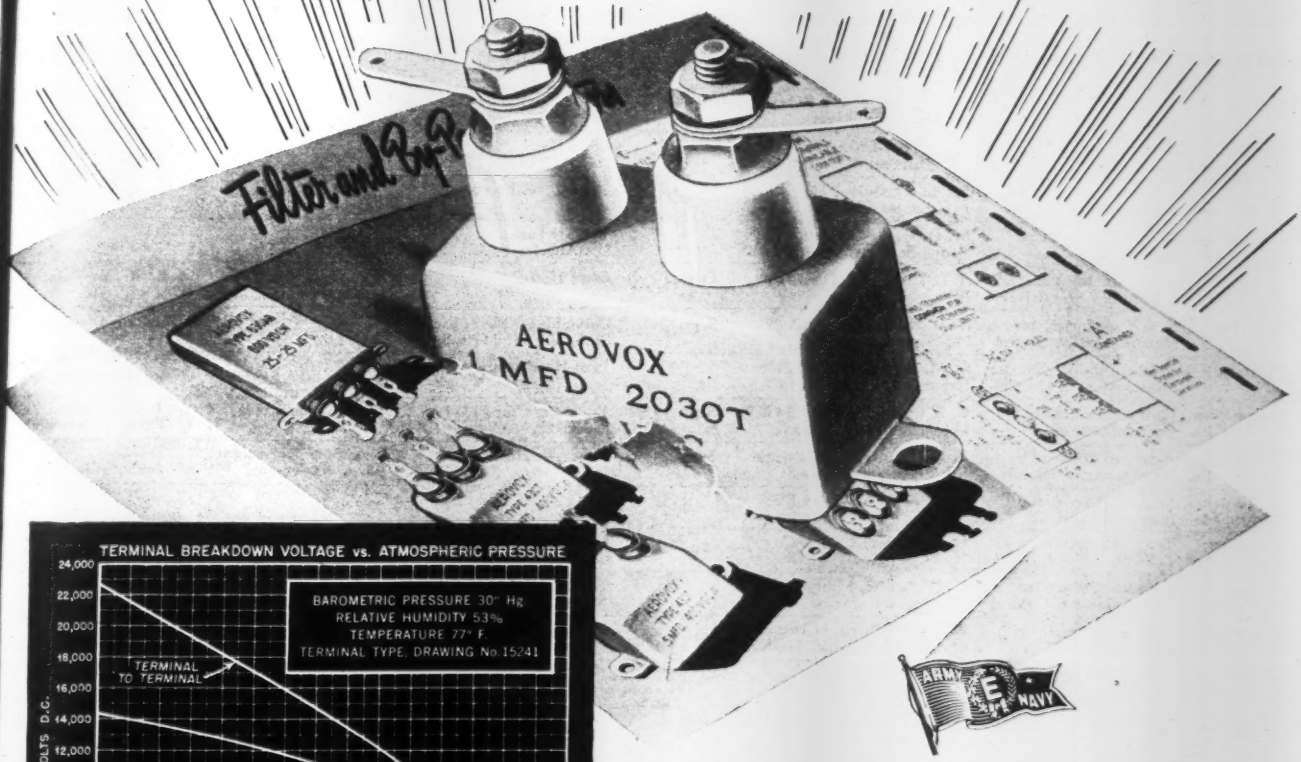

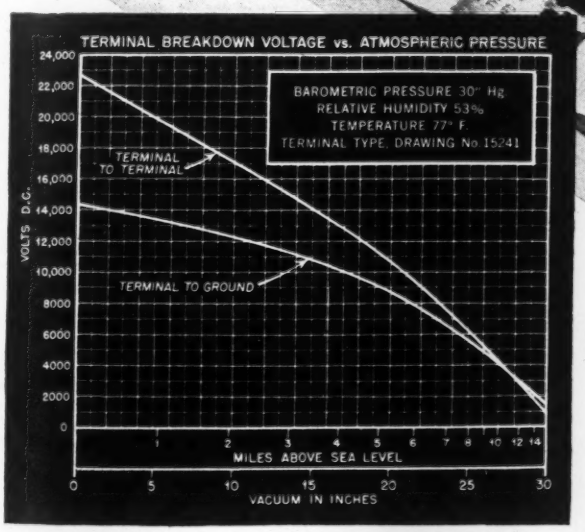

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INSTRUMENT SOCIETIES CALENDAR

City, Society and Secretary			Date	Place	Subject	Speaker
Atlanta, Georgia	Georgia Society for Measurement & Control	Robert E. Geminert, P.O. Box 1714, Atlanta		Blue Flame Room, Atlanta Gas Light Co.		
Baltimore Maryland	Baltimore Industrial Instrumentation Society	F. Ragan, Fuel Div., Beth Steel, Sparrows Pt., Md.		Engineers Club, 6 W. Fayette St., Balto.		
Charleston, W. Va.	Charleston Instrument Society	M. B. Lorig, 1506 Virginia St., Charleston 1				
Chicago, Illinois	Chicago Society for Measurement & Control	A. J. Butler, c/o IHC, 2626 W. 31st Blvd., Chicago		M&M Club, 237 Merchandise Mart		
Cleveland, Ohio	Cleveland Instrumentation Society	A. J. McCullough, Minneapolis-Honeywell, 5005 Euclid Ave., Cleveland 3		Cleveland Engineering Society		
Detroit, Mich.	Instrument Society of Detroit	Cliff Sackett, Chrysler Eng'g 12800 Oakland Ave. Det't				
Florence, Alabama	Muscle Shoals Instrument Society	J. W. Moffett, 323 E. Mobile St., Florence				
Fort Worth, Texas	Fort Worth Electronics Club	Ralph Ely, 1116 E. Arlington, Fort Worth		Texas Hotel, Fort Worth		
Gulf Coast (Texas)	Gulf Coast Instrument Maintenance Men's Ass'n	T. H. Pierson, 3030 Roberts St., Beaumont, Texas				
Hartford, Conn.	Hartford Society for Measurement & Control	Gustave L. Manke, c/o Veeder-Root, Sargent & Garden Sts.		Bond Hotel		
Kansas City, Missouri	KC Industrial Instrumentation Society	Gordon H. Burke, 1527 Broadway, Kansas City, Mo.		Bluebird Cafeteria		
Los Angeles, Calif.	California Instrument Society	M. D. Pugh, 541 South Spring St., Los Angeles, Calif.		Melody Lane, Los Angeles		
Newark, N. J.	Society for Measurement & Control (New Jersey)	H. L. Close, 831 Dixie Lane, Plainfield, N. J.	Oct. 2	Essex House	Air-operated control and applications	E. R. Huckman
New York, N. Y.	New York Society for Measurement & Control	H. L. Hildenbrand, 206-07 33d Ave., Bayside, L.I., N.Y.	Sept. 24	Columbia U. Men's Faculty Club, 400 W. 117th St.	(To be announced)	
N. Indiana	Northern Indiana Soc. for Measurement & Control	K. M. Frame, 25 Ruth St. Hammond, Indiana		Lake Hotel, Gary		
Philadelphia, Pa.	Philadelphia Society for Instrumentation	G. E. Gress, c/o ATC, 34 E. Logan St., Philadelphia	Sept. 19(B)	Engineers Club, 1317 Spruce St.	(To be announced)	T. F. Robertson, Corning Glass Works
Pittsburgh, Pa.	American Society for Measurement & Control	L. M. Susany, c/o Carnegie Institute, 4400 Forbes St.	Sept. 24(B)	Roosevelt Hotel	Electronic instruments for process control	D. M. Nielson, The Foxboro Co.
St. Louis, Mo.	St. Louis Society for Instrumentation	Gus Holubeck, Union Electric Co., Venice, Ill.				
Kingsport, Tenn.	Tennessee Section, I. S. A.	C. F. Palmer, 2924 J. C. Hwy., Kingsport				
Toronto, Ontario	Canadian Society for Measurement & Control	T. C. Agnew, Minneapolis-Honeywell Reg. Co.		Diana Sweets, 188 Bloor St. W., Toronto		
Washington, D. C.	Instrument Society of Washington	W. A. Wildhack, National Bureau of Standards, Wash'n		Interior Dep't Auditorium		
Whiting, Indiana	Whiting Instrument Men's Guild	Lloyd Clouse, 7344 Dante Ave., Chicago 19, Illinois				
Wyandotte, Mich.	Instrument Society of Wayne County	Wilson Fox, 33 Chestnut St., Wyandotte, Mich.	July 23	White Star Refining Co., Trenton	Conducted Tour	

(A) Meeting at 7:30, no dinner (B) Dinner at 6:30, meeting at 8 (C) Dinner at 7, meeting at 8 (D) Meeting at 8, no dinner

operation of these two types of catalytic cracking units. Considerable interest has been shown in this subject, as it is both new and different from the problems which have come before measurement men in the past.

—R. W. CHRISTIANSEN, *Publicity Chairman*

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

With meetings cancelled "meetings by mail" is the order in scientific and engineering societies. The AIEE's Summer Technical Program consists of numerous technical papers available by mail. *Instruments* is happy to publish descriptions of some of these technical papers which pertain to measurement and automatic control. Prices are given. Address: Order Dep't, AIEE, 33 W. 39th St., New York 18, N. Y.

Static Voltage Regulator and Rototrol Exciter; *E. L. Harder* and *C. E. Valentine. 25 cents.* Describes a new type of static control network for use in a rotating amplifier-type voltage-regulating system. The new network is a calculating-current type contrasted with the less efficient balance-voltage arrangements used previously. Analysis is given of the basic circuit and associated auxiliary circuits. These include a new circuit for securing polyphase response, provision for regulating at constant voltage in spite of frequency variation, and reactive droop compensation. Test results confirm the theoretical analysis.

Tachometer-Accelerometer-Vibrometer for Instrument Gyro Testing; *R. M. Laurenson* and *T. H. Long. 15 cents.* Tooling up for instrument gyro production required for development of certain items of special test equipment, among them an electronic instrument that combines 1,000-rpm and 15,000-rpm tachometers with a direct-reading accelerometer from −0.9 to −0.45 radians per second per second. The electrostatic coupling between the gyroscope and the measuring instrument does not perceptibly influence the gyroscope. The paper gives details as to circuit performance and calibration procedure and a brief history of the development.

Heat-Flow Effects in the Resistance-Type Thermometer; *N. P. Millar. 25 cents.* Specifications for the resistance-type temperature transmitter for aircraft applications are necessarily rigid with respect to accuracy and response. This presents a difficult problem from the viewpoint of testing, since there are several variables that must be controlled for reliability of test results. The most important variables affecting accuracy and response are evaluated for several conditions of test. This paper primarily outlines the fundamental equations that may be used in the solution of steady-state conduction problems, and an expression also is developed that describes the response performance of a typical bulb.

Response Time and Lag of a Thermometer Element Mounted in a Protecting Case; *W. N. Goodwin, Jr. 25 cents.* A thermometer element contained in a protecting case exchanges heat with an external medium indirectly through the protecting case. This increases the time of response and also increases the amount of lag. Equations are derived for the temperature of the thermometer element at any time for these two conditions. The equations are applied specifically to a resistance thermometer, but in general they apply to any body exchanging heat with a medium indirectly through another body. Equations also are derived and applications made to a resistance-type thermometer for the distribution of temperature, under static conditions, along the stem immersed in a constant-temperature medium, and for the resulting errors.

Automatic Regulation of Turbine Generators to Relieve Power-Supply Systems of Steel-Mill Load Swings; *W. W. Eberhardt, C. W. Harrison, E. F. Kohn* and *G. Daling. 30 cents.* The transmission of sudden heavy cyclic steel-mill loads over portion

Secretaries and Publicity Chairmen!

Keep your group in the news even during the no-meeting months! Send *Instruments* reports of committee work, items about individual members, etc.—MFB

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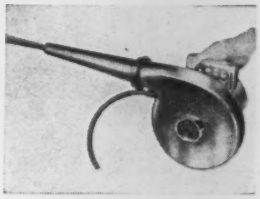

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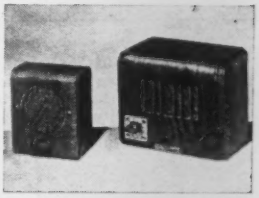

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extensive power-supply systems has used sufficient load-swing disturbances in certain instances to warrant correction. Relief for the external supply system from such condition has been obtained by a new static-load control which causes the steel-mill turbine generators to accept the variable mill loads with provision for modifying the amount of the enforced load according to available steam pressure. The conditions of the power-supply system, the mill loads, and available mill power supply together with a description of the load control and records of its effects are cited in the paper. Automatic Load Control for Turbine Generators; *F. E. Crever* and *R. L. Jackson.* 5 cents. Describes a load control for turbine generators installed on 20,000-kw turbines at the plant of the Tennessee Coal Iron and Railroad Co. at Fairfield, Ala., to reduce the load swings imposed on a tie line by a hot-strip mill. Previous to installation of the equipment described, the turbine generators carried load under control of their speed governors and variations in strip-mill load, which are about 20,000 kw, were imposed upon the power-company tie line causing disturbances on the power system. It was desired to develop means of imposing part of the strip-mill load on the Tennessee Coal Iron and Railroad Co. generators. The method selected was based upon a static watt-measuring circuit, the output of which in an Amplidyne generator which in turn operates the pilot motor of a hydraulic relay, at the turbine to control the steam admission valves.

Announcement of Prize Contest

THE AUSTRALIAN SOCIETY OF INSTRUMENT TECHNOLOGY

Mr. F. J. Henderson of Lorimier Contacts Pty. Ltd. having donated the sum of £5 to be awarded as a prize for the best paper on Instrument Technology, the Committee has instituted a contest to be known as "The Lorimier Contacts Pty. Ltd. Prize Contest."

Mr. Henderson expresses the hope that other instrument companies will donate similar prizes in the years to come, thus making the contest an annual one. His own Company is willing to donate more prizes in the future on these lines. In any year the contest would be named after the donor of the prize.

The Society is offering additional prizes and awards. It will be noted that the contest is not restricted to members of the Society, but entries will be received from any person.

The Rules are appended.

—P. A. CRIVELLI, *Honorary Secretary*

Rules of The Lorimier Contacts Pty. Ltd. Prize Contest.

Any person may enter for the contest and any competitor may submit any number of entries. The subject must be some application of instruments in industry, or allied thereto, or the solution of some instrument problem.

(2) Entries are required to be neatly written or typed in a form suitable for publication. Illustrations must be drawn in Indian ink on white card or be good black and white photographs, all suitable for reproduction. Papers must be written in clear grammatical English and should preferably be illustrated.

(3) The purpose of the contest is to stimulate interest in Instrument Technology and to encourage the publication of original work. Prizes will be awarded on this basis as far as possible.

(4) Prize winners must be prepared to present their papers before the Society in Melbourne not later than June 30th 1946, or as otherwise decided by the Judges. The Judges may waive or vary this condition if warranted by circumstances.

(5) All papers and illustrations become the property of the Society and are not to be returned. The Society reserves the right to publish any paper in whole or in part and to edit it in any way, due credit being given to the author.

(6) Papers must be the original work of the competitor, or joint competitors, and must be a constructive contribution to the design, use, application or handling of instruments under modern conditions in Australian industry. Competitors are advised to treat of either:

(a) One particular problem and its solution, or
(b) One type of industry, or
(c) An analysis of some broad question; such as research.

(7) Long quotations or extracts should be avoided. Sources of data facts and figures must be readily verifiable. Accuracy and authenticity are an essential condition.

(8) Prizes will be awarded in cash as follows:

1st. £25. 2nd. £10. 3rd. £5.

But the Judges may decide that any prize is not to be awarded should no entry be of sufficient merit.

In addition the author of any paper not awarded a prize, but considered of sufficient merit for publication, will be paid £2/2/-.

(9) There is no entrance fee. Entries should be sent in sealed envelopes, addressed "Contest," Australian Society of Instrument Technology, 93 William Street, Melbourne. The closing date is December 31st, 1945, and results will be announced at the Annual General Meeting in March 1946.

(10) The Judges shall be appointed by the Committee and their decision shall be final. The names of the Judges shall be announced in the *Australian Journal of Instrument Technology* before the closing date.

(11) Entries shall be accepted on the assumption that competitors agree to abide by these Rules.

Manufacturers' New Literature

In this department we report new literature pertaining to Instrumentation, received from the manufacturers. To assist in the War Effort we urge readers to request ONLY those bulletins which will be of value to them. Use the coupon on the facing page.

M-174 **Specialties in Machined and Fabricated Metals.** 22-page 8½" × 11" Catalog 451-A, descriptive and well illustrated, show the various steps and processes involved in the ancient art of metal spinning along with the more modern allied functions of welding, brazing, spot welding, machining, and assembly. A number of examples are shown such as relay racks, angle-front cabinets, power pack chassis, triangular mounting brackets, rack shelves, console frames and cathode-ray tube shield. A page giving the terms and conditions of sale along with several order forms are also included. Metallic Arts Company, 243 Broadway, Cambridge 39, Mass.

M-175 **"The CD Capacitor."** 16-page 5½" × 7½" February issue of this house organ features an article: Using Tube Characteristics, a reprint from "Radio and Television Retailing." There are also five pages of articles associated with radio listed for sale or trade and hard-to-get parts wanted by prospective buyers. Cornell Dubilier Electric Corporation, 1049 Hamilton Blvd., So. Plainfield, N. J.

M-176 **Testing Equipment.** 12-page 3½" × 6" booklet describes and illustrates many items of laboratory equipment: S-T-E Universal Testing Machines in capacities from 10,000 lbs. to 300,000 lbs. and to special order from 400,000 lbs. to 5,000,000 lbs. inclusive, Stress-strain recorders, plastic impact machines, fatigue testing machine which tests specimens up to 1" diameter, Gazan Mechanical Oscillator which is the mechanical equivalent of oscillating electric circuits, Flight Recorder for a knowledge of stress changes in planes in flight, Torquimeter, wind tunnel equipment. The Baldwin Locomotive Works, Southwork Division, Philadelphia, Pa.

M-177. **Electronics Controls.** 12-page 8½" × 11" Catalog Z-6300 presents a convenient condensed listing of principal items of equipment supplied by the company, describes the company's electronic principle by which control is effected without contact between measuring and control units of an instrument, and gives brief descriptions and prices of indicating pyrometers and pyrometer controllers, indicating resistance thermometers and resistance thermometer controllers, input controllers, program controllers, portable potentiometers, combustion safeguards, and thermocouples. Wheelco Instruments Company, Harrison and Peoria Sts., Chicago, Ill.

M-178 **Bearings, Mountings, Couplings for Machinery and Equipment in Motion.** 34-page 8½" × 11" booklet on flexible rubber. Well illustrated with pictures, charts, graphs and drawings. The table of contents lists (1) Rubber as a load carrying material, (2) Three services from Silentbloc, (3) General Silentbloc, what is it?, (4) Vibration absorption, (5) Torque action, (6) Misalignment correction, (7) Shock absorbing action. The General Tire and Rubber Company, Mechanical Goods Division, Wabash, Indiana.

M-179 **"The General Radio Experimenter."** 8-page 6" × 9" issue (identified as Vol. 19, No. 11) of this house organ designed for engineers, scientists, technicians, and others interested in communication frequency measurement and control problems features the following articles: (1) Microflash shows flight defects in projectiles, (2) Measuring 0.003 horsepower with the Strobotac, (3) Phototube capacitance measurement with the type 650-A impedance bridge. General Radio Company, 275 Massachusetts Ave., Cambridge 38, Mass.

M-180 **Generator and Vacuum Tube Volt Ohm Milliameter.** 2-page 8½" × 11" circular describes a square-wave generator designed to meet the demand for an instrument to be used in production and general testing. It is claimed to incorporate a feature not found in other generators, the facility of synchronization with any external frequency source. Vacuum tube volt-ohm-milliameter for laboratory work such as measuring amplifier gain, network response, output level. Power circuit voltages and high frequency voltages in transmitting equipment may be measured with the high voltage ranges. It is particularly suited to measuring audio-frequencies but also applicable for carrier current work, in supersonics, television and the broadcast field. Reiner Electronics Company, 152 W. 25th Street, New York 1, N. Y.

M-181 **Air Express Service.** 12-page 7½" × 10" booklet entitled "The Plane and Fanciful Trip of J. Orifice Blipp" contains numerous illustrations in color and provides useful information regarding Air Express for the speedy movement of shipments through the means of a nation-wide Air Express service. The Airlines represented are All American Aviation, American Airlines, Braniff Airways, Colonial Airlines, Chicago & Southern Airlines, Delta Airlines, Eastern Air Lines, Inland Air Lines, Mid-Continent Airlines, National Airlines, Northeast Airlines, Northwest Airlines, Pan American Airways, Pennsylvania Central Airlines, Trans-Canada Air Lines, Transcontinental & Western Air Lines, United Air Lines, and Western Air Lines. Railway Express Agency, Dept. of Public Relations, 230 Park Ave., New York 17, N. Y.

M-182 **Combustion Furnace.** 2-page 8½" × 11" leaflet describing the Glotemp combustion furnace, a complete furnace unit for efficient and rapid combustion of iron steel, or alloy steel samples as used for fast volumetric carbon determination with the No. 3000 to 31000 two-minute Carbon Determinator. May also be used to shorten the time of carbon determination when the gravimetric carbon determination is used. Harry W. Dietert Company, 9330 Roselawn Ave., Detroit 4, Michigan.

M-183 **"Lo-Volt Test-Glo."** Single sheet 8½" × 11" circular pictures and describes a low-voltage tester suitable for testing 5 to 50 volts a.c. or d.c. (Also available for testing 80-550 volt circuits.) When used as voltage tester, the brightness of "Test-Glo" indicates re[la]tive value of voltage. No light indicate[s] broken circuit. Particularly useful to [te]lephone repairmen, automotive and [air]craft mechanics and electricians. [Ge]neral Commutator Dresser Co., Sycamore, Illinois.

M-184 **Mercury Plunger [re]lays.** One-page 8½" × 11" Bulletin [illustrates] and describes a new improved type of normally-open mercury plunger relay which has an increased effective length of the magnetic plunger due to a small increase of overall length of mercury tube. The arc is broken over a new ceramic material. Bulletin includes price list, coil and load specifications. H-B Electric Company, 6122 North 21st St., Philadelphia 38, Pa.

M-185 **Precision-bore Glass Tubes.** 4-page 8½" × 11" Bulletin PB [508] pictures and describes precision-bore glass tubes which are available in cylindrical, tapered, oval, square or rectangular form. Normal tolerance of the inside diameter is ±0.01 mm. (±0.0004"). Closer tolerances available at additional cost. Furnished with bores from 0.13 mm. (0.005") to 100 mm. (4"). Bulletin also includes a list of stock sizes and list tube applications. Fish-Schurman Corp., 230 East 45th St., New York 17, N. Y.

M-186 **Micrometer-comparator.** 4-page 8½" × 11" circular pictures and describes combination micrometer and dial indicator comparator "Model 120 B-1" for production inspection and tool room use. Micrometer head obviates need of complete set of gage blocks for setting dial indicator to the required dimension. 1" and 2" gage blocks permit one to set gage to any dimension within 4" vertical capacity. Total vertical capacity is 5". Thread pitch diameters may be inspected by the three-wire method. Circular also includes specifications of several other models. Federal Products Corp., Providence 1, Rhode Island.

M-187 **Sapphire Gages.** 4-page 8½" × 11" circular describes and illustrates sapphire plug and ring gages which are claimed to outwear steel gages 300 times over. Plug gages available in plastic or flexible rubber handles. Ring gages available in sizes from 0.040" to 0.400". Tolerances range from 0.0001" down to 0.00005". Circular also includes technical data covering properties of synthetic sapphire and separate price list. Elgin National Watch Co., 932 Benton St., Aurora, Ill.

M-188 **Panel Electrical Instruments.** 4-page 8" × 10½" Bulletin GEA-4117 describes 2½" internal-pivot panel instruments intended primarily for use in aircraft to measure the current and voltage of the battery and battery-charging circuits. Includes table of ratings, dimensions, and price list of d-c. voltmeters, d-c. ammeters and d-c. volt-ammeters. Illustrated with photographs and cut-away view of instrument. Also includes construction details and condensed specifications. General Electric Co., Schenectady, New York.

M-189 **Gages and Inspection Instruments.** 16-page 8⅜" × 11" Booklet entitled "Millionths of an inch for sale by Vinco" illustrates and describes plain cylindrical plug and ring gages, straight-side spline gages, thread ring gages and masters, master gears, gear rolling fixtures, optical master inspection dividing head, master involute checker, spline and gear grinder and angle tangent radius checker. Vinco Corporation, Detroit, Michigan.

M-190 **Aircraft Tachometer and Synchroscope Testing Unit.** Single-sheet 8½" × 11" Data Sheet W-49 pictures and describes a unit which can check the indicated r.p.m. of four aircraft tachometers at the same time against a master chrono-tachometer. A variable-speed drive machine is used in connection with

testing pa... Unit also provides means for testing ... synchroscope. The Standard Electric T... Co., Springfield, Mass.

M-191 **Radio Parts Electronic Equipment.** 68-... 7" × 10" Catalog No. 345 covers p... cts of a large number of manufact... rs of radio and electronic equipme... available now. Practical reference ... buying directory with index, illustrati... descriptions, specifications and pric... Concord Radio Corp., 901 W. Jackson ... vd., Chicago 7, Ill.

M-192 **"The General Radio Experimenter."** ...-page 6" × 8⅛" March issue of this ... se organ features: (1) High-frequen... compensation for amplifiers, (2) Dyn... ic balancing in the field with the aid ... a stroboscope, (3) The use of variacs ... voltages above 230, (4) Rubber glo... tester uses variacs. General Radio C... 275 Massachusetts Ave., Cambridge ... Mass.

M-193 **"Norelco Electronic Products."** 8-page 8½" × 11" condensed catalog pictures and describes industrial x-ray equipment. The subjects covered are as follows: (1) Cathode-ray, transmitting, power and amplifier tubes, (2) Quartz crystal oscillator plates, (3) Searchray (X-ray) inspection units, (4) Geiger-counter X-ray spectrometer, (5) Film-type X-ray diffraction equipment, (6) Quartz crystal X-ray analysis unit, (7) Metallurgical products — tungsten and molybdenum powder, rod, sheet and wire. Also aluminum alloy, enameled copper, resistance, silver and gold-clad silver wire in fine sizes, (8) Medical X-ray equipment — radiographic units, tables, tubes, tube stands and miscellaneous accessories. North American Philips Company, Inc., 100 East 42nd St., New York 17, N. Y.

M-194 **Ammeters and Voltmeters.** 4-page 8½" × 11" leaflet pictures and describes d-c. voltmeters, d-c. ammeters, milliammeters suitable for motor-generator sets, battery charging equipment, test panels, tractors and automotive equipment. Cases available in 2" and 2½" sizes, and mountings available in several styles. Includes dimensions and specifications. Electro-Mechanical Instrument Co., Perkasie, Pa.

M-195 **Plugs, Sockets, Terminal Strips.** 34-page 8½" × 11" Catalog No. 14 illustrates and describes a complete line of multi-contact plugs and sockets, terminal strips, fuse mounts and barrier strips. Catalog includes larger illustrations of the No. 300 and No. 400 series lines plugs, dimensional data, drawings and current prices. Howard B. Jones Co., 2460 West Gearge St., Chicago 18, Ill.

M-196 **"Cenco News Chats."** 20-page 8" × 11" March issue (identified as Number 48) of this house organ features the following articles: (1) Technical Personnel, (2) Ellen H. Richards (noted woman scientist), (3) Events and Literature, (4) Selsyn Motors. Central Scientific Company, 1700 Irving Park Road, Chicago 13, Illinois.

M-197 **Polariscope.** 4-page 8½" × 11" circular pictures and describes a photoelastic polariscope for stress determination. The light source and polarizer are mounted on one section and the analyzer and projection system on the other permitting use of loading frame. Units are available in two sizes, one having 4½" aperture and the other 8½". Also includes illustrations of universal straining frame with tension test of flat bar with small hole, cylindrical roller under compression and rigid-frame bridge model in bending. The Polarizing Instrument Co., Inc., 41 East 42nd St., New York 17, N. Y.

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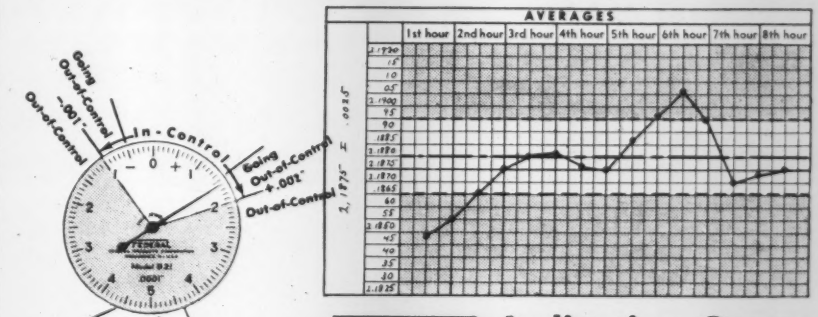

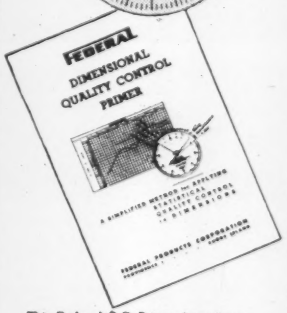

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